INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

OCTOBER 1958

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. . . ALSO EXCLUSIVE FALL RIG LOCATOR

Dowell Guide to Acidizing

1. Paradox Lime
San Juan County, Utah

1. This formation is both vugular and highly soluble. Good results often occur after a wash of Mud Acid, followed by Retarded Acid or regular acid with surface tension and emulsion control agents added. Acid volumes range from 1500 to 10,000 gallons or more. *Wells often potential more than 1000 bopd.*

2. Noodle Creek Lime
Jones County, Texas

2. This vugular pay reacts quickly with regular acid. For this reason an acid with retarded action has been used. Typical treatment is 250 to 500 gallons regular acid containing surface tension, anti-emulsion and silicate control agents; followed by 1000 to 5000 gallons of the slow reacting fluid used in Acid Petrofrac®. *Wells producing from 16 to 45 bopd often increase to 80 to 125 bopd.*

3. Chester Lime
Beaver County, Oklahoma

3. Reaction time is usually less than one minute in regular acid. As a result, Retarded Acid is usually recommended. The following three-stage treatment has proved successful: (1) 500 gallons Mud Acid; (2) 500 gallons regular acid with surface tension and anti-emulsion agents added; (3) 5000 to 20,000 gallons Retarded Acid injected at rates up to 30 bpm. *Some previously non-commercial wells have potentialed 20 million cfd after treatment.*

4. Townsend Wolfcamp
Lea County, New Mexico

4. This dolomitic limestone is found from 10,400 to 11,100 feet. Some sections have crystalline porosity. Some are fossiliferous, and some are vugular. Treatment with either 10,000 gallons Retarded Acid or 3000 to 20,000 gallons regular acid has been successful. A wash with Mud Acid ahead of the main treatment is recommended. *Wells have potentialed 300 to 500 bopd after treatment.*

5. Many new wells in the Midale Beds get good drill stem tests, but produce only a show. Treatment is often a 500 gallon wash of Mud Acid followed by 500 to 2000 gallons Dowell regular acid with anti-emulsion, surface tension, and silicate control agents added. Injection pressures are held to 1000 psi or below to minimize water troubles. *After treatment, wells have potentialed 80 to 100 bopd*

5. Mississippian Lime
Southeastern Saskatchewan

6. This flashy formation reacts fast with regular acid, so Dowell has used Retarded Acid to increase penetration, drainage area and production. Typical treatment is 500 gallons Dowell acid with surface tension and de-emulsifying agents added, followed by 3000 to 4000 gallons Retarded Acid. *Potentials are often increased from a show to 240 bopd.*

6. Lansing-Kansas City Lime
Barton County, Kansas

With 41 different acid addition agents to choose from, Dowell engineers can help you "tailor" the best acid treatments to the requirements of your well. Call your nearest Dowell engineer. Let him tell you how Dowell acidizing services have helped other operators in your area get higher production from their wells. Have Dowell acidize your wells. Dowell, Tulsa 1, Oklahoma.

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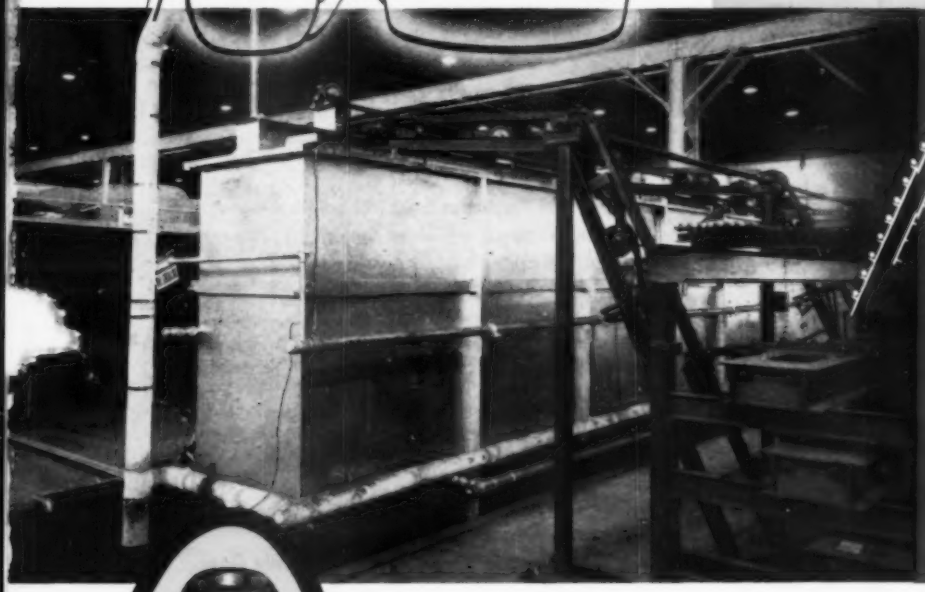
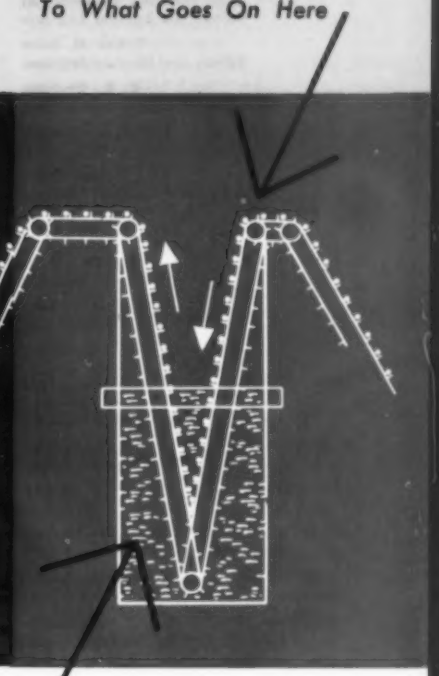
**Grandma's Method Was Good — But It Couldn't Hold A Candle To What Goes On Here*





All grease, oil and foreign matter disappear in Steam Bath leaving metal bare.

Norris Rod
photographed on assembly line
after leaving degreaser.

. . . in LARGEST, MOST MODERN SUCKER ROD PLANT in the Oil Industry!

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the Petroleum Engineer

FOR MANAGEMENT

NUMBER 11 • VOLUME XXX • OCTOBER, 1958

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— *James McNeill Whistler*

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FOR MANAGEMENT
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The Grand Detours

Like *la grand tours* of the 19th century that gave young blades a broader perspective, the profusion of detours sprinkled over the United States this year will open new vistas to young Americans and old.

If you made a motor trip this year you know that to the nation's farthest corners, bands of bare earth are being scooped, scraped and shaped into the greatest system of roadways ever built. The first impressive results of the $50 billion highway program can be used right now and from the detours you can begin to visualize the sweep and the grandeur of the road network that will spread across the land.

The equipment is awe-inspiring. We saw one mechanical dinosaur swirl down an incline at about 50 miles an hour, moving a bigger load of dirt than a hundred coolies could carry. What a nation — that can build these efficient monsters and energize them so one man can do the work of a hundred!

The economic force this giant project will release is incalculable. Bottlenecked traffic has slowed automobile sales and oil products consumption. The needs of a motoring public have slowly been frozen.

The petroleum industry has already felt the first impact of the construction work and demand will increase in coming years. Herbert O. Jason predicted in THE REFINING ENGINEER that asphalt sales would rise to 137 million barrels annually during 1960-67. Of this, 56 million will go into highway construction and 50 million barrels into existing highway maintenance.

Asphalt is not the only product that the great roadways will call for. Good roads beckon the traveler and more motorists invite new service stations, motels, restaurants, and market places.

The detours will always be with us — we trust — for they are a symbol of more and better highways. And even the detours, you've probably noticed, are covered with a hasty spread of asphalt.

The time is not far off when you'll be able to drive from coast to coast on smooth divided highways — by-passing narrow city streets. A new car and a motor trip will be almost irresistible.

And when you see the fair face of America, your love of your country will be freshened. Young Americans can taste at first hand the beauty of their nation and feel the warmth of growing patriotism. Can we not hope a by-product of the grand detours will be a cleansing of parasitic clinging — a resurgence of the spirit of freedom and independence?

Ernestine Adams

Congrats and $25 to Doug Foster, Atlantic Refining Co., Dallas, Texas

Drilling for and producing oil and gas is a rugged business demanding great risk and courage. More, it requires plenty of rugged, dependable pipe. That's why Lone Star Steel was established in the heart of oil country.

The huge Lone Star plant, a modern miracle of automation and quality control, makes the kind of tough casing, tubing and line pipe American Petroleum Institute specifications call for. And, as Joe Roughneck knows, Lone Star offers a real convenience in fast, economical delivery.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.

Lone Star STEEL COMPANY

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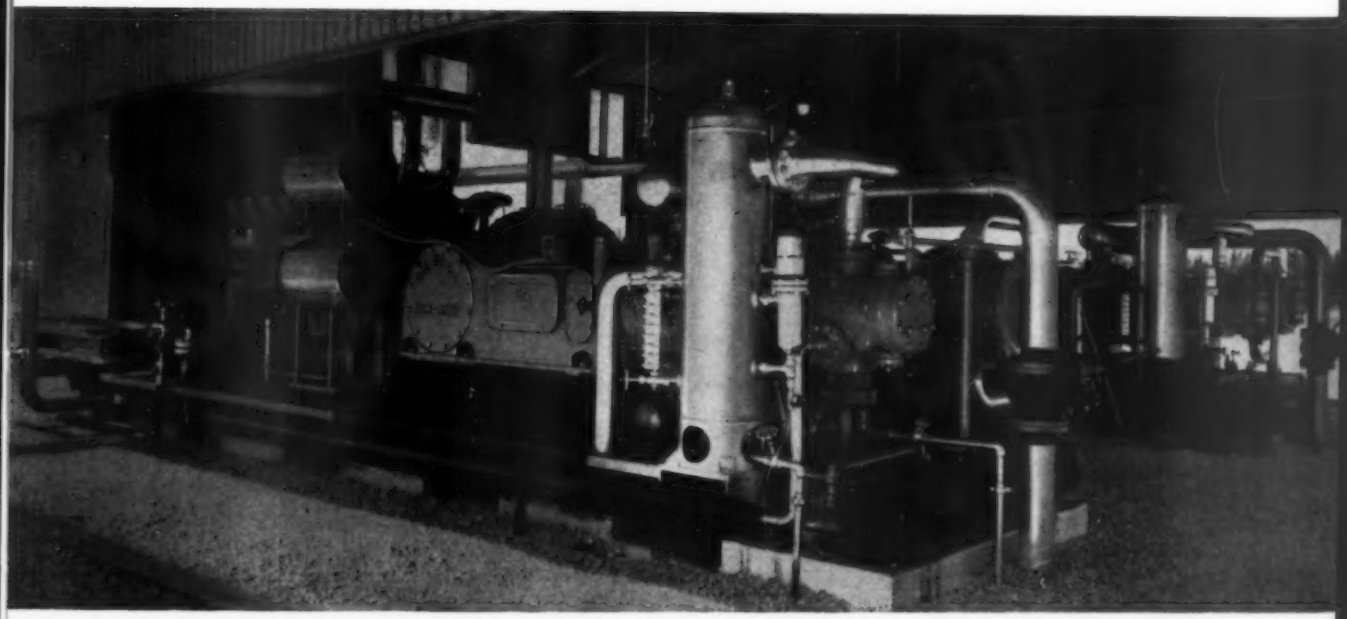
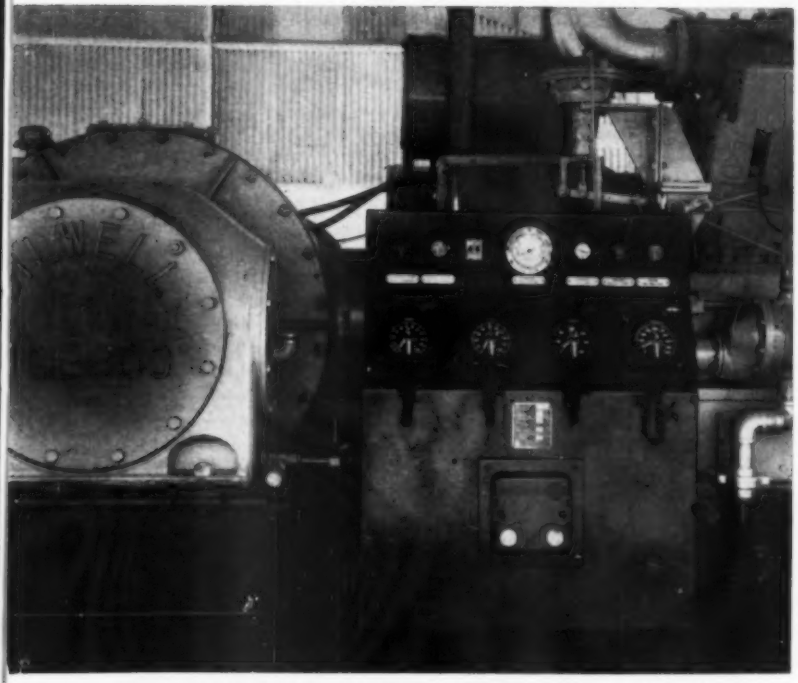


Boost gas economically with "Oilwell" Slow-Speed Gas Compressors



All gauges and safety controls are grouped and mounted on a shock-resistant panel for operating convenience.

Near Lake Charles, Louisiana, these "Oilwell" DGE-300 Gas Compressors are being used in an interesting combination gas-lift, gas-sales application. The gas is boosted through three stages—from 10 psig inlet pressure to 1,050 psig discharge pressure—and air-cooled after each stage through tube-and-fin vertical radiators. Each unit operates at 277 rpm and can handle approximately 1,125,000 standard cubic feet of gas per 24 hours.

The units consist of tandem compressors mounted side by side and driven by a single gas engine through a fully enclosed, right-angle, spiral-bevel gear transmission. Together with cooler, scrubber, and automatic controls, everything is mounted on a single heavy-duty skid base with integral piping.

"Oilwell" Gas Compressors range from 25 to 300 hp and can be furnished to perform a wide range of gas-handling functions. Contact your "Oilwell" representative for information about the money-saving advantages of an "Oilwell" slow-speed compressor for your gas-moving operations.

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The Petroleum Profile

From oil portrait of Mr. Joseph N. Pew, Jr., by Charles J. Fox, noted American painter

Joseph Newton Pew, Jr.
Chairman of the Board
Sun Oil Company

Discouraging depression and anti-business political climate honed down the spirit of enterprise in the '30's. Business and industry crouched in fearful quiet, victimized by a foreign economic theory.

It was in this atmosphere that Joseph N. Pew, Jr., then vice president of Sun Oil Company, pushed construction of a gasoline pipeline from the company's Marcus Hook refinery to the Great Lakes. Not only did engineers say it couldn't be done (it hadn't been done before) but hardly anybody thought $6 to $7 million should be put in one project when economic conditions were close to paralysis.

Like many of Joe Pew's ideas, the project went through as he planned. He did a lot of the work, too. He helped obtain 1058 permits to cross highways, 161 to cross railways, 33 for electric lines, 37 federal permits to cross rivers and canals, and 671 state permits to cross smaller streams. He headed the staff that acquired 3300 easements on property from landowners.

And the result? It gave Sun Oil low cost distribution in the East and Midwest and improved its income. Howard Pew, his brother and then president, once said, "The depression was in many ways our best period."

Mr. J. N. Pew got into politics during this same depression. He was not particularly opposed to President Roosevelt until the New Deal tried to insert price fixing in NRA; then he was outraged. To him price fixing was and is now an "evil, wicked thing."

At that time the opposition Republican party was shattered and lifeless so the black-browed, six-foot crusader in a business suit started out to pick up some pieces. Almost alone he brought the GOP back to life in Pennsylvania.

But the key to the forceful Joe Pew is not his ability to achieve the impossible—it's his capacity to forego power. Political satraps are still agape when they remember how Mr. Pew sailed for Europe after his influence elected Arthur H. James governor of Pennsylvania. James was free to name his own cabinet without seeking the approval of his political backer. It was probably a unique episode in U. S. politics.

The Pews have been in the oil industry since its early days. Joseph Newton, Sr., was the son of an early settler in Mercer County, Pennsylvania, who bought leases soon after the Drake well. He married Miss Mary Anderson, whose family were pioneers in Titusville oil business. In 1901 he organized the Sun Oil Company and headed it until he died in 1912 when his sons, John Howard and Joseph, Jr., took over Sun Oil management. Today Sun is the 12th largest U. S. oil company in net worth.

Mr. J. N., Jr., celebrated 50 years with the company in June 1958. He began work soon after he received his degree from Cornell University in 1908. It was a question whether his engineering major or his track record was more help in those early years when he worked in the field, helped lay pipeline, and repaired refining facilities. But his inquiring mind outraced the athlete. He pushed the establishment of Sun Shipyard in 1916, staked the future of Sun Oil on the first long distance products pipeline, advocated financing the Houdry process, conceived the idea of coloring Sun's gasoline blue. He continued as vice president—we might say, vice president of ideas—until 1947 when he became chairman of the board.

In 1916 he married a pretty Philadelphia girl, Miss Alberta Caven Hansel. They have three daughters, all married, and a son, Joseph Newton Pew, III.

In an article on America's 10 richest men (one of which is Joseph N. Pew, Jr.) the author said all 10 have two characteristics—vision and ability to size up men. Mr. Pew has these qualities, certainly; he is also a distinguished and effective defender of individual freedom. In business, Sun Oil Company sometimes stands alone because of the chairman's views on economic freedom. Sun is one of a few, for instance, not in the Voluntary Imports Program; yet, characteristically, the company is doing its share of holding imports down. In politics Joe Pew often takes the line of greater resistance because of deep belief in individual authority and responsibility.

A deft leader, he nevertheless hews to an unpopular line if it provides room for his principles. And the core of his belief is that we must promote "that freedom which brings out the best in all men . . . which makes the American republic stand out in this sick world."

CAT FUEL INJECTION EQUIPMENT CUTS COSTS BY PROVIDING MAXIMUM ENGINE PERFORMANCE

Presetting at factory for accurate performance eliminates field settings, makes installation of Caterpillar fuel injection pumps quick and simple.

The fuel injection system is a key to peak engine performance. It must deliver to each cylinder equal amounts of fuel at precisely the right time. Deviation means a loss in horsepower. That's why it pays to use Cat fuel injection equipment.

Cat injection equipment can save you money in other ways, too. No field or operating adjustments are necessary. Installation is *quick and simple*. All pumps are interchangeable for different cylinders and between engines of the same model.

This interchangeability permits smaller parts inventories, makes replacement inexpensive by eliminating custom fitting, and makes replacement possible in a matter of *minutes* right on the job regardless of the experience of the mechanic.

Genuine Caterpillar injection equipment is built to last. With clean fuel, a life of 20,000 service meter hours is not unusual.

Pumps, plungers and barrels are manufactured from the finest chromium alloy, so hard that diamond dust is required for lapping the plungers and barrels. Pumps are tested and preset at the factory to provide accurate metering, timing and fuel pressure.

HIGHEST STANDARDS in the industry go into the manufacture of Caterpillar fuel injection equipment. Pump plungers and barrels, for example, are finished to tolerances so fine that the heat from your hand will expand a plunger enough to make it larger than the matching barrel.

SERVICE TIP

Your Caterpillar Dealer has the testing equipment to determine accurately when fuel injection systems parts should be replaced. And testing is the only sure way of knowing.

RUN-IN TESTS—four hours on pumps, two on valves – are conducted on these Caterpillar-built test machines before a pump or valve leaves the factory. Strict testing procedure means perfect performance of genuine Caterpillar injection parts.

Single-orifice fuel injection valves minimize the possibility of clogging or fouling. A spring-loaded plunger within the valve opens by fuel pressure at the proper time for uniform and precise injection. Extra protection is given by a fine-mesh screen. This clean, accurate injection means less down time and lowest fuel cost per unit of power.

Don't risk real damage to your Caterpillar equipment with an improperly functioning fuel injection system. Test systems regularly and replace worn parts with genuine Caterpillar parts. Your Caterpillar Dealer has the full story. See him today. And remember, he stands behind every part he sells.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

Improper fuel injection equipment can be expensive. For instance, if a machine's owning and operating cost is $10 per hour, its total cost in a 2,000-hour season is $20,000. For a 200-horsepower machine that's $100 per horsepower. A poorly functioning fuel injection system which robs the machine of 5% of its horsepower (10 HP) could mean a season loss of $1,000 (10 [HP] x $100). Don't take chances. Standardize on Cat equipment.

CATERPILLAR

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THE CONFERENCE TABLE

"The work of the master reeks not of the sweat of the brow." — JAMES MCNEILL WHISTLER

Upswing in Profits

British Petroleum Company has certainly done all right the first half of 1958. Net income reached $72.6 million as against $62.7 million the first half of 1957—a satisfying 16 percent increase. U. S. companies for the first half were down 34 percent.

Sir Neville Gass, chairman, reported also that sales the first half of 1958 amounted to 31 million tons compared to 22 million tons for a like period of 1957. This is a startling 41 percent increase. B-P stockholders received a 100 percent stock dividend in addition to the regular semi-annual dividend which amounts to approximately 13 cents per share.

This unusually good report at this time will make you more than ever interested in reading what Sir Neville has to say about "The Future for Oil." On page E-5 this month he gives an interesting analysis of what oil needs in the United Kingdom will be in 1970. He believes demand will double and that it could treble.

★ *I am not afraid of tomorrow, for I have seen yesterday, and I love today.* —William Allen White

New Company Emerges

Signal Oil and Gas Company and Hancock Oil Company, two of California's largest independent oil companies, have joined into one integrated company, with Signal as a surviving corporation.

The colorful histories of the two companies have many striking similarities. Both companies grew to their present size from very small beginnings on Signal Hill and Long Beach over 35 years ago and both have remained independently owned and operated.

The Hancock Oil Company was founded by the late John Walker Hancock and his brother, Lemuel A. Hancock. John Walker Hancock was the father of John W. Hancock, who has been president of the Hancock Oil Company since 1953. The company attained its greatest growth under the guidance of Will J. Reid, one of the founders of the company and its first president, who was chairman of the board until his recent death.

During those same years Signal was attaining its present status in the oil world under the direction of Mr. Reid's long-time friend, Samuel B. Mosher, who founded Signal and served as its president until last March when he was named board chairman.

Both organizations are pioneer oil producers and marketers of petroleum products. Their total domestic oil production is approximately 65,000 bbl per day, plus approximately 12,500 bbl per day natural gasoline and liquefied petroleum products. Natural gas sales amount to 70,000,000 cu ft per day.

Hancock has been a refiner for many years, as well as the operator of a sulfur recovery plant. Plans are under way to rebuild Hancock's Long Beach refinery which was partly destroyed by fire with a new plant that will be enlarged and modernized to meet today's marketing demands. New refining facilities will be undertaken for the group in the San Francisco Bay area as well as in the Northwest.

Signal is a natural gasoline manufacturer operating plants in California, North Dakota, and Oklahoma. Signal also owns approximately a 50 percent interest in the American President Lines, one of the largest shipping organizations in the world with headquarters in San Francisco.

Together Signal and Hancock have participated in many oil ventures in the United States as well as abroad. Jointly they own the famous Signal-Hancock offshore leases in Huntington Beach, California. They each own a 28½ percent interest in the Long Beach Oil Development Company, operators of a large oil property in the harbor area for the city of Long Beach.

Internationally, the two companies own a total of 50 percent in a 43 square mile concession in Lake Maracaibo, Venezuela, where to date a total of six wells have been completed and tested for a combined total of approximately 40,000 bbl per day. Two rigs are currently drilling on this concession, which could well be one of the most important oil reserves ever developed by independent oil companies.

The two companies own identical oil interests in Iran and in the Kuwait Neutral Zone. In Iran their joint interests amount to approximately 10,000 bbl of oil per day, while in Kuwait the companies will jointly own a 30 percent interest in the American Independent Oil Company, which operates a large oil concession in the Kuwait Neutral Zone. Total net production of the new company from these Middle East holdings approximate 25,000 bbl per day.

Officers will be: Samuel B. Mosher, chairman of the board and chief executive officer; Russell H. Green, president; and the following vice presidents: Harold F. Clary, B. H. Dresser, Charles Reid Gaylord, John W. Hancock, William T. Hancock, Ronald W. Heath, O. W. March, J. Howard Marshall, N. D. Taylor, William E. Walkup, and Garth L. Young; E. P. Ludman, treasurer; A. E. Stebbings, secretary; Gerald F. Krause, controller.

★ *Freedom is not worth having if it does not connote freedom to err.* —Mahatma Gandhi

School of Individual Enterprise

Although Junior Achievement began way back in 1919, only recently has it been growing and expanding vigorously. American industry, thrown on the defensive in its battle for individual as opposed to governmental enterprise, woke up to find a whole generation had grown up who sincerely believed the government could handle business and industry better than private firms. Now the "learn by doing" program is nation-wide; some 3900 companies are organized, sell stock, produce an item and try to sell it at a profit.

The petroleum industry has done its share to foster the small companies operated by high school students. Last year 150 of these were counseled by firms in the petroleum industry—either oil and gas companies or suppliers. The story on E-14 will give you a good idea of exactly how the plan works. If your company hasn't tried it, perhaps you should look into it.

Forecast by Science Fiction

We were entertained by Crawford H. Greenewalt's ideas of forecasting the future. Mr. Greenewalt, who is president of E. I. du Pont de Nemours thinks that science fiction writers of early days have a better score than scientists. He firmly believes, also, that progress is not made because we decide we need a particular thing, but because of scientific curiosity to see if a thing can be done. (Page E-4).

Soviet Economic Offensive

We have pointed out several times indications of the Russian use of economic tools in politics. At an international science foundation recently President's Committee Chairman Dr. Howard L. Bevis cited the following: "Stepped up Russian exportation of coal, copper, oil, cotton, and manufactured products into Britain and Western Europe increases the free world dependency on Russia for raw materials and manufactured goods."

The Soviet has increased its aid to under-developed countries, which now amounts to $2 billion yearly. Although the U. S. has given some $60 billion and now provides almost twice what USSR is spending, we apparently fail to get credit for the taxpayers' burden of raising almost $4 billion for friends and neutrals. We need to spend more on publicity and less on good works.

Reynolds Review (Reynolds Metal Company magazine) recently carried an article "Made in Russia" which described the Soviet's upsurge in light metal exports. The president, R. S. Reynolds, Jr., stated "Russia is using aluminum as its weapon in an attack aimed directly at the U. S. This is economic warfare. If not checked, it could be fully as devastating to our freedoms and living standards as a military war."

As we said in the July issue of *The Petroleum Engineer*, "Oil companies face USSR competition," we found that Russia made some gains in 1957 in countries near its territories. (Also see page E-34.)

The question is, can private companies compete with a foreign government that can manipulate economics without thought of stockholders, employees, profits, taxes, etc.? Can private enterprise with economic purpose compete with a state whose objective is political conquest?

Decline Levels Off

Chase Manhattan Bank reported that August demand held to same level as July this year. "Averaging 8,827,000 bbl per day, total demand, including exports, was about 1.0 percent better than a year earlier. A similar gain was registered for the average movement of the past three months. For the year to date, there was a decline of 3.4 percent.

"Domestic demand alone displayed more favorable comparisons. For August there was an increase of 2.5 percent; the three months average was up 3.0 percent; the year to date was ahead by 1.1 percent."

★ *When you argue with a fool be sure he isn't doing the same thing.*

Award Winning Editors

Oil editors of 28 company publications received awards at the International Council of Industrial Editors annual convention in Washington, D. C.

First Awards went to: Donald L. Tullsen, *The Texaco Dealer*, The Texas Company; Ellis Prudden, *The Texaco Star*, The Texas Company; Allan B. Carleton, *Horizons*, Pan-American Petroleum Company; Gene Hill, *Philnews*, Phillips Petroleum Company; and Nathalie Ronis, *Distributor*, Cities Service Petroleum, Inc.

Awards of Excellence were bestowed on: William H. Jones, *The Standard Oiler*, Standard Oil Company of California; Thiel D. Collett, *On Tour*, Union Oil Company of California; C. R. Lyman, *Bulletin*, Standard Oil Company of California; F. J. Bjornsgaard, *Sunoco Diamond*, Sun Oil Company; Walter G. Beach, *The Humble Way*, Humble Oil & Refining Company; Richard O'Brien, *Cycler*, Champlin Oil & Refining Company; D. D. Dickinson, *The Shell Review*, Shell Oil Company; Walter M. Sanford, *Sun Production & Pipeline News*, Sun Oil Company; and Ted McCall, *B-A Topics*, British-American Oil Company, Ltd.

Receiving the Certificate of Merit were: Leon M. Sipes, *The Inch*, Texas Eastern Transmission Corporation; A. B. MacFayden, *Imperial Oilways*, Imperial Oil, Ltd.; John Earl Davis, *Shell Progress*, Shell Oil Company; Howard J. VanDyke, *The Link*, The Carter Oil Company; Bud Schauerte, *The Conocoan*, Continental Oil Company; and O. F. Kolb, *The Shell Roar*, Shell Oil Company.

Special Citations went to: William H. Burns, *Our Sun*, Sun Oil Company; Frank D. Praytor, *The Trunkliner*, Trunkline Gas Company; Carl I. Huss, *Standard Torch*, Standard Oil Company (Indiana); and Thiel D. Collett, *On Tour*.

Back to School

Thirty-two college engineering students returned to the campus after spending the summer months in the laboratories and largest oil refinery of Sun Oil Company. Of course, Sun is only one of many oil companies which make it possible for college students to work for oil companies during the summer. They work in the field holding production or drilling jobs, on seismic crews, on pipeline crews, and in processing plants.

Sun Oil has sponsored this summer student program since 1945. The company has always been forward looking in its program for its own personnel, as well as its responsibility for further education. Many students go back to permanent careers with Sun after their studies are completed.

Be interested—don't try to be interesting.
Be pleasing—don't expect to be pleased.
Be entertaining—don't wait to be entertained.
Be lovable—don't wait to be loved.
Be helpful—don't ask to be helped.

Executive Courses Popular

For over a year now, we have been carrying a series of articles on management courses given by different universities and colleges in the United States and Canada. We sincerely believe that one of the most important developments of recent years is the increased and more effective effort to create better management for our companies.

The universities and colleges, both private and state-supported, have done a wonderful job in building these unusual and exciting executive development programs. They are varied, for each company (as well as each person) needs its own specialized type of program.

For instance, on page E-21 we describe a management course at the University of Cincinnati that holds three classes weekly. These top management students naturally come from the local area. The course in Banff University described in the June issue, requires 6 weeks consecutive study at Banff, Canada, and it draws attendants from coast to coast. Some universities, like Louisiana State, develop courses to fit a specific need in a company.

Please turn to Page A-17

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

New Imports Rules in Effect

Certificates of compliance are now being issued to crude importers whose imports for the last three months were not in excess of their average allocation. Under the new rules, issued by Captain M. V. Carson, administrator of the voluntary oil imports program, certificates are being issued on request and may be required by federal agencies in awarding contracts for purchase of petroleum products. Carson indicated that the regulations provide mechanics for an importer to obtain a certificate if he can prove that excess imports are due solely to transportation problems. Also, an importer may claim compliance if his actual and estimated imports between April 1 and December 31 do not exceed his daily average allocation for the 9-month period. The new rules are limited to Districts 1, 2, 3 and 4, east of the Rockies.

Union Hits 'Cartel,' IOCC

O. A. Knight, president of the Oil, Chemical and Atomic Workers Union, has gone on record as saying that free trade in the oil industry is a thing of the past. Quoted in an AFL-CIO magazine, Knight named seven international oil companies in the cartel which "manipulated" world oil flow and prices and the Interstate Oil Compact Commission, and had pushed state conservation groups "to a corner" where they must bow to desires of the international group. Knight called the companies a "super government" and urged that the five American companies in the group be deprived of all tax depletion allowances and not be allowed to register their tankers under foreign "flags of convenience."

Kermac Opens Foreign Division

A foreign exploration division has been established by Kerr-McGee Oil Industries, Inc., under the direction of J. C. Finley, vice president. In addition, Finley is responsible for matters pertaining to acquisition of domestic properties. Exploration activities in the United States and Canada are now handled by Harold J. Kleen.

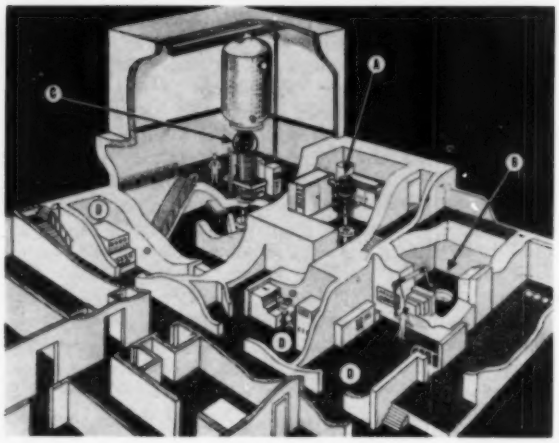
Signal Builds New Home

Construction of Signal Oil and Gas Company's new $5,000,000 home office building is scheduled to begin next month. The 15-story structure will overlook downtown Los Angeles, California, from its location west of the Harbor Freeway. It will be completed early in 1960 and will include three level parking within the building. Most of the office space will be occupied by Signal.

New Title for Course

"Learn Emergency Management" was the subject of a U. S. Government course described in the September 1958, issue of *The Petroleum Engineer*. Since the article was written, the title has been changed to "Learn the Economics of National Security," according to Kenneth F. Zitzman, Brigadier General, USA.

At this time more than 6000 executives have completed the correspondence course and close to 1000 are working on it. Any company interested in one of its executives learning national emergency economics can write: The Commandant, Industrial College of the Armed Forces, Fort Lesley J. McNair, Washington 25, D. C., Attention: Correspondence Study Branch.



Texaco's radiation laboratory, in Beacon, New York, is one of the world's most fully-equipped industrial nuclear research lab and is first to use four basic radiation forces. Maze of massive walls, shown here, vary from 3½ to 7 ft thick, shielding operators from powerful radiation sources. (A) indicates the lab's 8 to 10-million v linear accelerator, only one of its kind now in use for industrial radiation research. (B) is lab's "hot cell" containing the largest single shipment of radioactive Cobalt-60 received from Canada. Rated at 29,100 curies, Cobalt source is packaged in 156 stainless steel "pencils." When not in use, source is lowered by automatic elevator into 17 ft of water in well shown. Hot cell is shielded by 3½ ft of high-density concrete, 4½ ft ceiling, and has 13-ton entry door. (C) indicates 3-million v Van de Graaff generator. (D) indicates operating rooms of respective installations.

Kettleman Hills Celebration

Kettleman Hills oil field, in Kings County, California, is 30 years old. The anniversary is being celebrated October 10-12 with the "Kettleman Gusherado"—complete with beauty contests, barbeques, football games, reunion breakfasts, dances and guided tours through the field. Drilling in the field has set several world's depth records. Quality and quantity of botn oil and gas have set records through the years.

Exploration Down in Canada

Geophysical operations in Western Canada continued their downward trend this year. In mid-August there were 83 crews at work—some 20 less than at same time last year. For the first eight months of this year, there was an average of 94 geophysical crews working. Biggest decline was noted in Alberta. Imperial Oil Ltd. employs the largest number of crews, with 14 working parties, six of its own and eight contract crews.

Coal Group Asks Oil Cut

National Coal Association has announced plans to seek a curb on residual oil imports on the East Coast by asking for relief under a provision in the new Reciprocal Trade Agreements Act. It is asking "immediate remedial steps" to restrict imports that are said to be cutting heavily into coal's traditional markets on the Atlantic Seaboard. A protectionist provision of the Trade Act, according to NCA officials, is a "clear mandate from Congress to relieve essential industries like coal from the damage done by foreign imports."

Major South Texas Operator* Achieves 22% Increased Condensate Recovery With . . .

BS&B Model GDH "COLD-FRAC" Units

Down in Kleberg County, Texas, a major lease operator had 10 shut-in gas condensate wells which were to be put "on stream". The problem was to extract the *maximum* amount of condensates consistent with the *lowest* possible cost, and to lower water dewpoint of the gas to below pipeline contract specifications before it reached the sales line.

Three BS&B Model GDH "COLD-FRAC" Units were installed with stage separation capacity totalling 40 MMSCFD. Based on the following flow conditions, condensate recovery from the 10 wells increased 22% over conventional separation and water dewpoint is well within maximum limits:

Low Temperature Separator:
Operating at 855 psig and 11° F. top—51° F. bottom.

Gas Capacity:
40 MMSCFD maximum.
Operating at 25 MMSCFD with 2960 psig flowing pressure and 106° F. flowing temperature.

*Name furnished on request

If you are not now using a BS&B Model GDH "COLD-FRAC" Unit on your lease, get your nearby BS&B Man to make a complete engineering analysis of your lease production to determine the potential increase in condensate recovery you could realize from a GDH installation! Why not call him now?

OVER 60 YEARS EFFICIENCY BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Oilfield Equipment Division, Dept. 1-C10
P. O. Box 1714
Oklahoma City, Oklahoma

Signal-Hancock Finalize Merger Plans

Directors of Signal Oil and Gas Company and Hancock Oil Company have unanimously agreed on merger proceedings already underway. Signal becomes the surviving corporation with approval of the stockholders. Resulting organization is a half-billion-dollar integrated major oil company with 65,000 bbl of domestic oil production; gasoline, natural gasoline and sulfur recovery plants in California, North Dakota and Oklahoma; foreign operations in Venezuela, Iran and in the Kuwait Neutral Zone.

Plans are in progress for the immediate rebuilding of Hancock's Long Beach refinery, which was partly destroyed by fire earlier this year. Hancock trade name will continue to be used and its marketing program will be stepped up in the western states.

Gulf to 'Politicize' Against Labor Inequities

Gulf Oil Corporation has declared its determination to take increased interest in politics particularly in the field of labor. The company indicated that its complete program will not be ready for much to be done in 1958 elections. It is encouraging its shareholders—who number 161,000—to become more active in politics in their individual communities. Senior Vice President Archie D. Gray states that "Whether we want to be there or not, Gulf and every other American corporation is . . . up to its ears in politics, and we must either start swimming or drown."

NPA Asks 'Anti-Trust' Definition

The time has come for the federal government to define its anti-trust policy and to make its enforcement of its laws realistic and consistent, declares Guy B. Hunter, president of the National Petroleum Association. Hunter, also board chairman of Quaker State Oil Refining Corporation, pointed out anti-trust inconsistencies at the recent NPA annual meeting. He noted the so-called cartel case, in which several companies are charged with conspiring to restrain competition by restricting the importation of oil; at the same time this case is pending, Hunter says, "the government has called upon the same companies to reduce their imports of crude oil under a voluntary plan."

'Mixed Emotions' Greet Imports Plan

Administrator of the Voluntary Imports Program, Captain M. V. Carson is finding that the government's attempt to please oil men and at the same time maintain a stable oil economy is extremely difficult. Captain Carson has asked oil associations, companies and individuals for their opinion of the proposed revised imports programs to go into effect January 1, 1959. The suggested plan would be based on allotment of imported oil in proportion to companies domestic refining capacity.

Companies whose imports quotas would be cut under the new arrangement are, of course, opposed. In this group are Atlantic, Tidewater, Gulf, Stancal, Sun, and Eastern States. Comments from this group are that the plan is "grossly unfair" and "astonishing." Atlantic announced its intention of withdrawing from the program.

Due to gain from the change are Standard of New Jersey, Standard of Ohio, Standard of Indiana, Sunray Mid-Continent, Texaco, and Conoco. Swearingen of Standard of Indiana hails the program as "a tremendous advance."

Associations are divided in the controversy. Some say it is much better, but others point out that the West Coast should have been included in the program.

Egypt Buys More Russian Oil

Egypt's imports of Russian oil and oil products reached record levels in 1957, according to *Vneshnyaya Torgovlya* (Foreign Trade). Official Soviet figures show that the USSR delivered 5,700,000 bbl of oil products and 2,400,000 bbl oil to Egypt last year. In 1956, Russia delivered 4,700,000 bbl oil products and 3,700,000 bbl crude to Egypt. Totals for 1955 were 1,300,000 bbl and 1,200,000 bbl, respectively.

Oil and oil products accounted for about 32 percent of the total value of Soviet exports to Egypt last year—by far the largest item. Russia noted that it was the "contractor" for 37 percent of all Egyptian oil imports in 1957.

The Soviet Union also sharply increased its oil trade with Syria—the other member of the United Arab Republic—in 1957. Petroleum products represented 24 percent of Russian exports to Syria last year, totaling about 4,200,000 rubles ($1,050,000 at the official rate of exchange).

Meetings

Oct. 15-17—**NACE**, north central region meeting, Cincinnati, O.

Oct. 16-17—**AIME**, Southern California Petroleum Section, fall meeting, Biltmore Hotel, Los Angeles, Calif.

Oct. 16-19—**Permian Basin Oil Show**, Odessa, Tex.

Oct. 19-21—**National Assn. of Oil Equipment Jobbers**, annual convention and trade show, Adolphus Hotel, Dallas, Tex.

Oct. 20-24—**NACE**, annual conf. & exhibition of South Central Region, Roosevelt Hotel, New Orleans, La.

Oct. 22-24—**Purchasing Agents Assn. of Tulsa**, petroleum industry purchasing management seminar, Western Hills Lodge, Wagoner, Okla.

Oct. 22-24—**API Committee on Disposal of Refinery Wastes** meeting, Statler Hilton Hotel, Dallas, Tex.

Oct. 23—**AIChE**, 1958 All-Day Symposium, Statler Hotel, New York City, N. Y.

Oct. 23-24—**WPRA**, El Dorado regional technical-industrial relations meet, Rufus Garrett Hotel, El Dorado, Ark.

Oct. 23-24—**Rocky Mountain Oil & Gas Assn.**, annual fall meeting, Town House Motel, Omaha, Neb.

Oct. 23-25—**National Society of Professional Engineers**, fall meeting, St. Francis Hotel, San Francisco, Calif.

Oct. 26-31—**American Institute of Electrical Engineers**, general meeting, Pittsburgh, Pa.

Oct. 27-28—**IPAA**, annual meeting, Statler Hilton Hotel, Dallas, Tex.

Oct. 27-29—**National Lubricating Grease Institute**, 26th annual meeting, Edgewater Beach Hotel, Chicago, Ill.

Oct. 31—**NGAA**, Southern regional meeting, Carlton Hotel, Tyler, Tex.

Nov. 6-7—**AAPG**, Pacific section, annual meeting, Los Angeles, Calif.

Nov. 10-13—**API** 38th annual meet, Conrad Hilton Hotel & Palmer House, Chicago, Ill.

Nov. 17-19—**NACE**, western region meeting, Los Angeles, Calif.

Nov. 19-21—**Society of Petroleum Engineers**, Local Sections, Venezuela.

Nov. 21—**NGAA**, Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Nov. 28-Dec. 4—**Electronic Computer Symposium and Exhibition**, Olympia, London, England.

Nov. 30-Dec. 5—**ASME**, annual meet, Statler & Sheraton-McAlpin hotels, New York City, N.Y.

Dec. 2-4—**The Asphalt Institute**, annual membership meeting, Shoreham Hotel, Washington, D. C.

Dec. 3-5—**API Oil Information Committee** meeting, Waldorf-Astoria Hotel, New York City, N.Y.

Dec. 7-10—**American Institute of Chemical Engineers**, annual meeting, Netherland Plaza Hotel, Cincinnati, O.

1959

Jan. 23—**NGAA**, Oklahoma regional meeting, Biltmore Hotel, Oklahoma City, Okla.

Feb. 9-11—**AAPG**, Rocky Mountain Section, 9th annual meeting, Civic Auditorium, Albuquerque, N. M.

Feb. 15-19—**AIME**, annual meeting, Sir Francis Drake Hotel, San Francisco, Calif.

Feb. 16-19—**AAPG-SEPM**, 44th annual meeting, Memorial Auditorium, Dallas, Tex.

Mar. 1-5—**ASME**, gas turbine power conference & exhibit, Netherlands-Hilton Hotel, Cincinnati, O.

Good Wells Make Good News

A Monthly Report of Successful Well Treatments

October, 1958

Acidizing has come a long way since its use was limited to wells producing from simple limestones. Today, Dowell offers acids for many kinds of formations, from fast-reacting vugular or fractured limestones to slow-reacting dolomites and dirty sandstones. In addition, acids are available with addition agents designed to remove or prevent nearly every kind of permeability block. Here are four recent examples of special Dowell acidizing jobs:

- **Beaver County, Oklahoma.** (New Gas Well) This well was completed through perforations into the Chester lime from 6869 to 6927 feet. Two Dowell treatments were used. First, 1000 gallons Mud Acid was pumped down the casing to clean up perforations. In the second treatment, 20,000 gallons low-surface-tension acid was pumped down casing at 40 bpm. Treating pressures during last treatment ranged from 1550 down to 1000 psi. Before treatments well tested 3660 mcfd. After Mud Acid, it tested 20 mmcfd. *Following the final acid treatment, it tested 78 mmcfd.*

- **Alberta, Canada.** (Old Oil Well) This well was originally completed in 1950. The producing formation was the D2, and completion was open hole from 5000 to 5040 feet. Well had produced about 90,000 barrels of oil in eight years; but, at this point, production was nil and fluid level in the well was only 65 feet. The producer then had Dowell acidize using 5000 gallons Retarded Acid. Average injection rate was 5 bpm at pressures ranging from vacuum to 2200 psi. *One month after treatment, production had leveled off at 100 bopd flowing. Gas-oil-ratio was 250.*

- **Big Horn County, Wyoming.** (Old Oil Well) This well had been producing from the Tensleep formation and was re-completed in the Embar lime. Laboratory tests of produced fluid indicated severe emulsion problems. Formation samples contained substantial quantities of sulfates. Dowell suggested an acid with a demulsifying agent plus calcium chloride. The demulsifying agent was proposed to prevent tough emulsions from forming. The calcium chloride was used to keep the acid from dissolving and re-precipitating formation sulfates. Well was treated with 6000 gallons acid with demulsifying agent and 17,500 pounds calcium chloride. *Before treatment, well swabbed 2.5 boph. After treatment, well tested 22 boph — flowing.*

- **Logan County, West Virginia.** (Old Gas Well) This well was completed open hole in the Big Lime formation from 2671 to 2713 feet. It had produced little gas even though the offset was good. To clean up and acidize the formation, the operator ordered this three-stage treatment from Dowell: (1) 1000 gallons regular acid with Deterger® added to suspend materials blocking the formation. (2) 4000 gallons Retarded Acid to extend drainage area in the fast-reacting limestone. (3) 3000 gallons regular acid with Deterger. Well had been producing 10,000 cfd. After treatment, it gauged over one million cfd. *Treatment costs were paid out in two weeks and entire well cost was recovered in five months.*

Let your Dowell engineer help you "tailor" an acid treatment for your well. For service or more information, call any of the 165 Dowell service points and offices. In Canada, contact Dowell of Canada, Ltd.; in Venezuela, contact United Oilwell Service. Dowell, Tulsa 1, Oklahoma.

Services for the oil industry DOWELL

A SERVICE DIVISION OF THE DOW CHEMICAL COMPANY

Also check larger, heavy-duty 305. On crawlers, it lifts up to 15-tons (based on conservative 75% rating) — handles ¾ to 1-yard clamshell or dragline bucket, converts to ¾-yard shovel or hoe. Tractor-type crawlers, independent traction optional. Koehring 305 also available as a 25-ton lift crane on truck, or 18 m.p.h. Cruiser mounting.

Works and runs on fast schedule

On lifting and material-handling work, where distance between jobs is a problem, take advantage of the high-speed mobility, and *extra capacity* of Koehring 205 truck crane. It travels anywhere a truck will go — can be 30 or 40 miles from "here" in less than an hour.

With one of these mobile cranes, you're equipped to lift any load up to 15 tons (based on 85% of tipping load). For high lifts, 25-foot boom can be lengthened to 70 feet. For extra reach, 15 to 30-ft. jib can be added to 65-foot boom. Stability of truck mounting increases the 205's work capacity with every attachment. It handles ½ to ¾-yard clamshell or dragline buckets on a wide work-radius — and quickly converts to pile-driver, ½-yard shovel or hoe.

This heavy-duty 205 also is available as a 15-ton Cruiser® crane, or 10-ton crawler crane — with all standard attachments. On rubber-tired Cruiser mounting, you get travel speeds up to 21½ m.p.h. — *plus* economical one-man operation for both work and travel.

Next time you're in the market for a crane or excavator, look into this 205. Your Koehring distributor has complete facts and figures that will interest you. See him soon or write us.

K840

KOEHRING DIVISION OF KOEHRING CO. Milwaukee 16, Wisconsin { *Koehring excavators, cranes also built in:* CANADA • ENGLAND • SPAIN • JAPAN

Tricky Statistics

The population of this country is 160 million, but there are 62 million over 62 years of age, leaving 98 million to do the work. People under 21 total 54 million, which leaves 44 million to do the work. Then there are 21 million who are employed by the government and that leaves 23 million to do the work. Ten million are in the Armed Forces, leaving 13 million to do the work. Deduct 12,800,000 housewives, who actually do nothing but housework, and that leaves 200,000 to do the work. There are 126,000 in hospitals, insane asylums, and the like, and that leaves 74,000 people.

But 62,000 of those are derelicts or others who will not work, so that leaves 12,000 to do the work.

It may interest you to know that there are 11,998 people in jail, so that leaves just two people to do all the work. And that is you and me, and, brother, I'm getting tired of doing everything myself.

Does U. S. Promote Monopoly?

The oil industry is one of the victims of "Monopoly in America" (The Macmillan Company, New York) by Dr. Walter Adams, associate professor of economics at Michigan State University and Dr. Horace M. Gray, professor of economics at the University of Illinois.

The publishers promote this as a challenging book with a refreshingly realistic look at the problems of the government policy toward business.

The authors managed to get in most versions of criticisms about the oil industry. "The depletion allowance amounts to a perpetual grant of immunity from the federal corporation income tax within the 50 percent of net revenue limitation."

Another familiar remark is the statement, "If the government were truly concerned with conservation, it would lift the present restrictions on oil imports." After taking that whack at the independents, the book concerns itself with "the international oil trust" naming the five companies in an anti-trust suit filed in 1953. In other words, the authors have managed to step on nearly all segments of the oil industry. Nevertheless this is advised reading. You can't argue a case if you don't know the opposition's arguments.

It is in the essence of things that from any fruition of success shall come forth something to make a greater struggle necessary . . . Walt Whitman

Staff Meets Line Promotion

Several companies have changed their organization charts in order to give more recognition to their scientists and engineers. They know that research engineers and scientists have left their specialized work to get into the administrative side of company business in order to step up in the firm.

Latest company to inaugurate a new plan for promotion and recognition of outstanding research scientists is Continental Oil Company. The announcement that this would be tried in the company's Development and Research Department of Ponca City, Oklahoma, was announced by E. R. Baker, department manager.

"The program insures equal advancement opportunities for Conoco's true researchers who prefer to stay in their chosen scientific field rather than take line assignments and assume administrative and supervisory responsibilities," said Mr. Baker. "We feel it will provide us with another important tool to help our research program maintain its healthy growth.

"Under the plan, scientists will be appointed to new research positions on the basis of their creative ability and their scientific contributions to the company," he added. "The positions are comparable to the top supervisory positions in the department and will enable outstanding scientists to realize long range career opportunities in the fields in which they were trained.

"Now, with this new technical advancement ladder, Conoco can assure the scientist working solely in the scientific field the same opportunities for advancement as his counterpart who chooses the supervisory or administrative route."

Under the program, the new titles of Research Associate, Senior Research Associate and Research Fellow have been established in Conoco's development and research department. The Research Fellow is comparable to the supervisory position of Division Director. The plan also provides that additional positions may be created at the top of the advancement ladder.

Above and Beyond Business

The Union Oil Company of California's company magazine "Seventy-Six," edited by Thiel D. Collett, reports one of the nicest gestures we've heard of for a long time.

Called Operation Friendship, it includes visits to the homes of all those retired from the company's Oleum refinery. If they were too far away, of course, letters were sent. Supervisors gained information about all of the 143 retirees. Each one was invited to an "Old-Timers Day" down at the refinery and each was given a bound year-book with the names, addresses, retirement date, physical condition, hobbies, interests, etc., of all 143 men contacted.

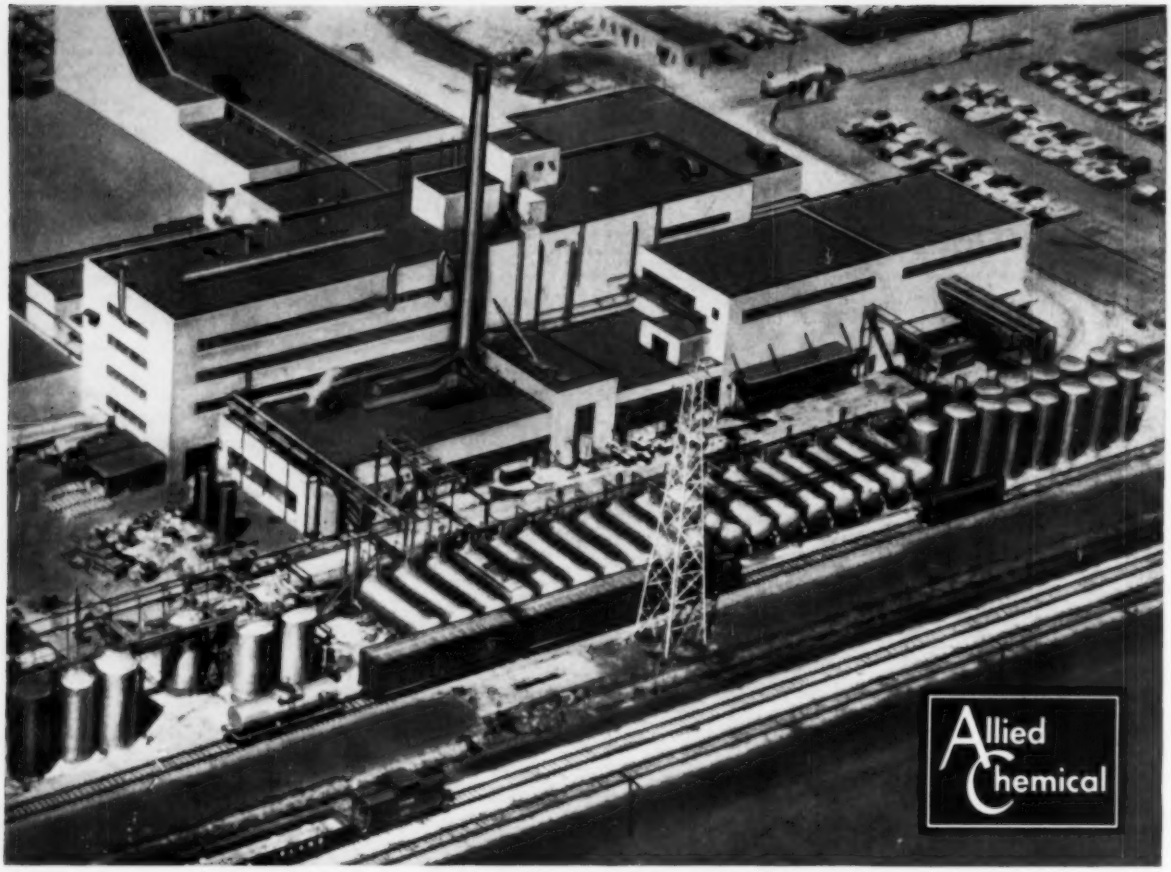
Some of the busiest men in Union Oil Company handle Operation Friendship but that is usually the case—the busiest people find time to do extra curricular projects. In this case benefits have been rewarding to the energetic supervisors and to ill and lonely retirees, as well as the happy, healthy ones who like to talk about their old jobs and see their old friends again. As you can imagine, it has warmed the hearts of their families and communities. It is an operation that gains friends everywhere.

To Every Oil Man

Every phase of road construction and the highway transportation field, from modern technological developments, like the use of electronics in surveying, to fundamental topics, to the development of a national highway system, will be covered when the world's foremost road experts gather at Mexico City, Mexico, October 26-31, for International Road Federation's III World Meeting.

IRF is a non-profit service organization which promotes world roadbuilding through its member road associations in 64 nations in the free world. More than 50 nations will be represented by their best road authorities, top government officials and prominent business leaders.

Although in this meeting not one mention is made of the petroleum industry, it is still one of the most important conventions so far as our industry is concerned. The biggest limiting factor on wide travel in the United States, in Canada and down through South America is lack of roads. When the international highways of the world are expanded and strengthened, the petroleum industry must be prepared to supply a surge of demand.



Polyester and Phenolic Resins Plant—Toledo, Ohio
Plastics and Coal Chemicals Division, Allied Chemical Corporation

COORDINATION COUNTS

The Plastics and Coal Chemicals Division required installation of its new Polyester and Phenolic Resins facilities without plant shutdown or interruption of other production.

Synchronizing its operations with those of the client, Catalytic completed the job as required . . . ahead of time and under the budget.

With Catalytic—On Time—On Budget is far more than just a slogan.

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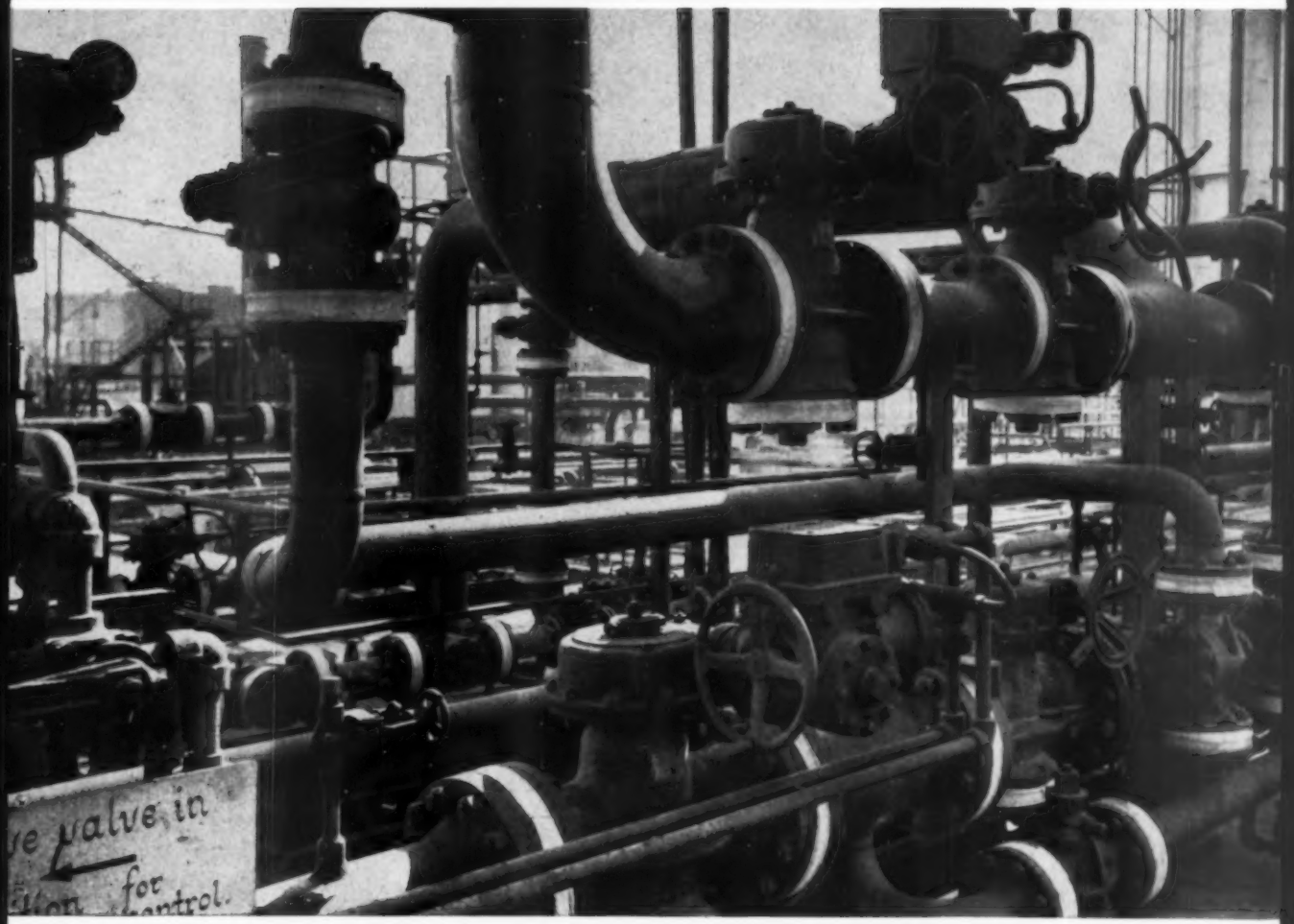
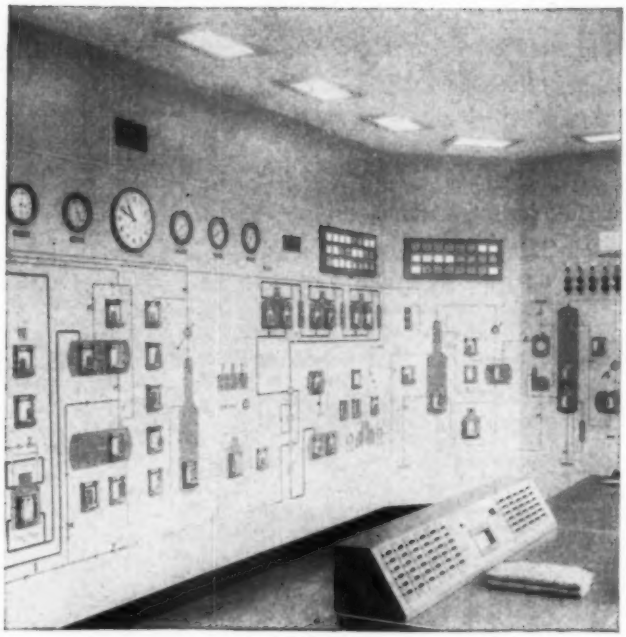
In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario; Toronto, Ontario; Montreal, Quebec.

Catalytic *On-Time* . . . *On-Budget* Services for the metallurgical, chemical, petrochemical and oil refining industries: Project Analysis; Process Development; Process Design; Economic Studies; Engineering; Procurement; Construction.



BUT, WHERE IS EVERYBODY?



Relays click . . . motors whir . . . lights flash . . . *valves open and close.* With a minimum of human attention, the modern refinery practically thinks for itself. Basic to this complex, continuous processing are dependable valves. Where operation *must* be foolproof, where shut-off *must* be positive every time, most refinery engineers have standardized on Rockwell-Nordstrom lubricated plug valves. Why? Smooth, easy quarter-turn operation and pressurized lubricant sealing mean shut-off that can be counted on day after day . . . year after year. Rockwell-Nordstrom is the *original* and world's *most complete line* of lubricated plug valves and plug valve lubricants and accessories. Write for complete details. Rockwell Manufacturing Co., Pittsburgh 8, Pa., Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES

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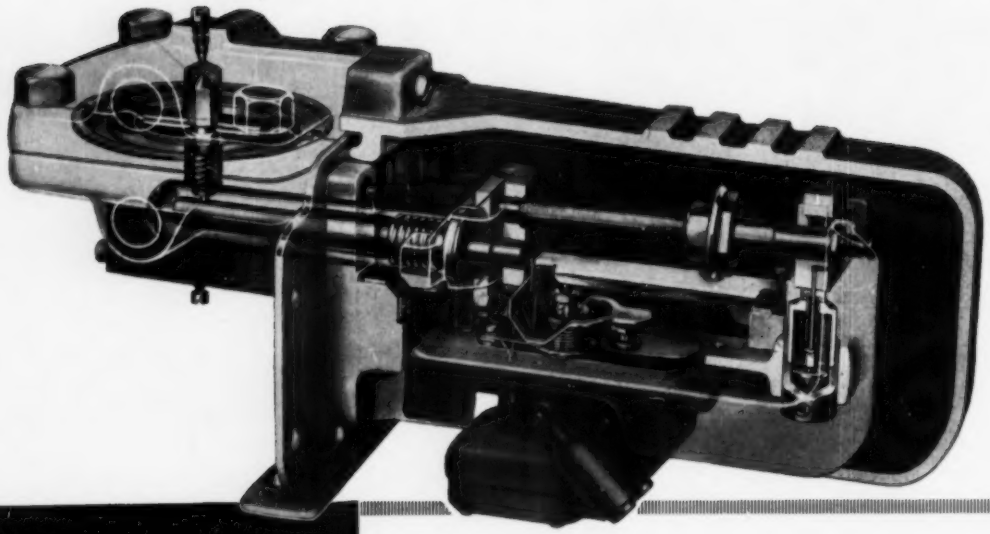


For full-range control of flow and liquid level

...there are now three HONEYWELL *Differential Converter* models

1. *For measuring gas and water flows:* The new model has a range of 0-5 to 0-25 inches of water. It can also be adapted to the measurement of specific gravity of liquids in open tanks.
2. *For measuring liquid level in closed tanks:* One model has a range of 14 to 50 inches of water, with maximum suppression of 75 inches. Another model, with a range of 50 to 200 inches of water, has maximum suppression of 200 inches.
3. *For measuring flow and liquid level in open tanks:* Two models with ranges from 0-20 to 0-200 inches of water differential and 0-100 to 0-1000 inches.

A mercuryless remote pneumatic transmitter with a range that is continuously adjustable between 0-5 and 0-25 inches of water has just been added to the Honeywell *Differential Converter* line. Now you can choose a standard transmitter for any range from 0-5 to 0-1000 inches of water . . . a choice of ranges offered by no other manufacturer.

The *Differential Converter* measures gas and liquid flow or liquid level with accuracy within ±1% . . . and with rapid response, upscale and down. Range is continuously adjustable in the field, without parts change, and field calibration check is easily accomplished with weights. Air consumption is extremely low.

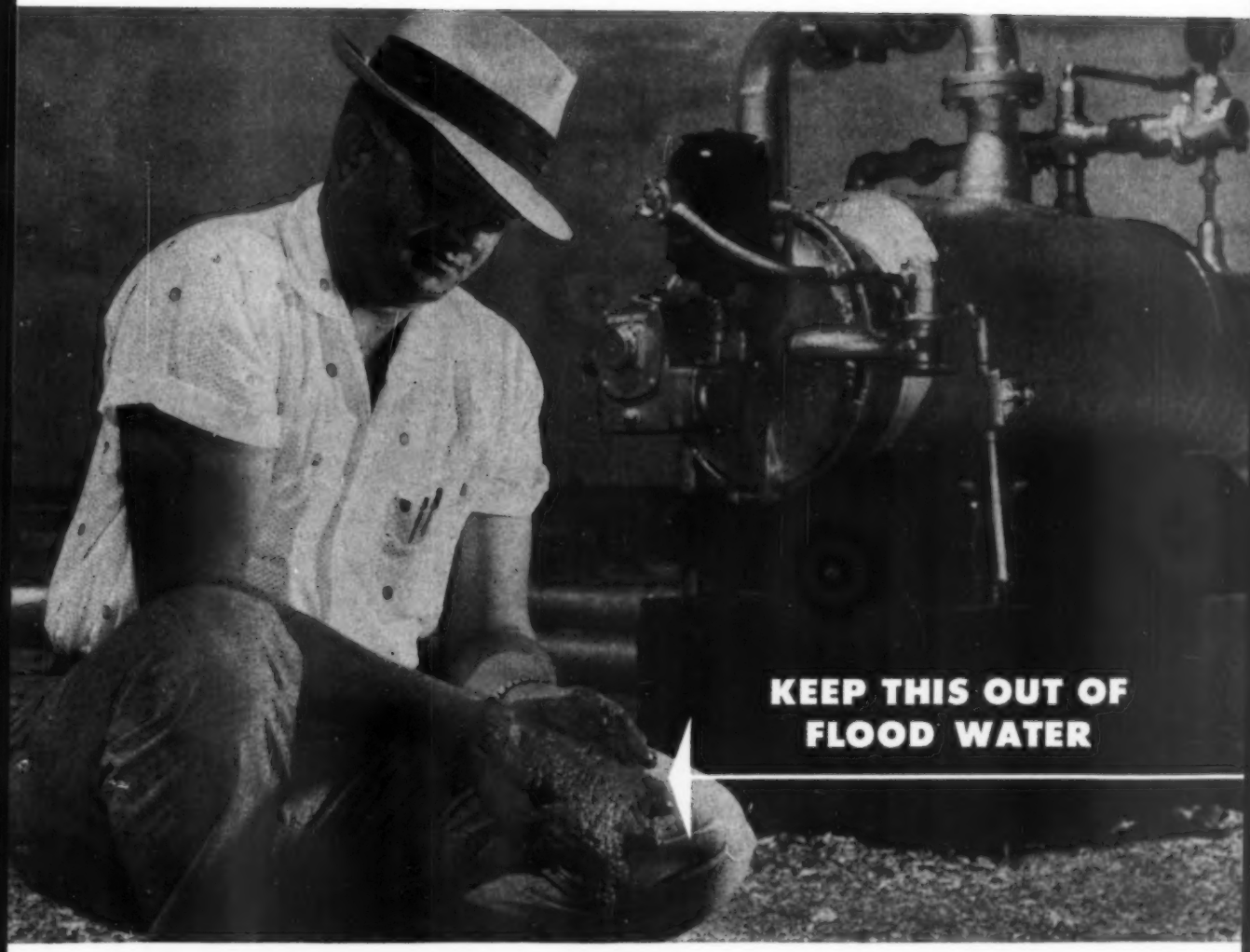
Compact and lightweight, these transmitters can be mounted anywhere. They're ideal companions for Honeywell *Tel-O-Set* miniature instruments. Call your nearby Honeywell sales engineer for details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA:** Write for Bulletin 2290-1, "*Differential Converter* Liquid Level Transmitter"; Catalog 2321, "Flow Meters," and Specification 248, "*Differential Converter* Flow Transmitter."

Honeywell

H HONEYWELL *First in Control*



Self-cleaning JET STRAINERS put clean water in the formation... more oil in the tank.

Clean water is a must for successful water-flooding. Injection water containing sand and other solids can form a permanent block in the formation. Workovers to remove the solids from the well bore do not always restore free circulation since a portion of the solids may enter and penetrate the formation. Additional horsepower is then required to force the flood water through the obstruction. It all adds up to a more expensive, less effective water-flood operation.

The T-C Jet Strainer has proved most successful in removing solids from flood water. Using a bare 400-mesh screen, it removes solids down to 31-micron particle size. With diotomite filteraid, it removes sub-micron solids . . . even algae and bacteria.

But that's only part of the story. T-C Jet Strainers can be cleaned and returned to service in less than five minutes. They never require backwashing. Push a button and revolving jets go into action, scouring the screen and flushing the solids out of the strainer. A pressure-differential gauge notifies the operator when the strainer needs cleaning. The cleaning operation may be made completely automatic, if desired, with electronic controls of the operator's choice.

Gallon for gallon of strainer capacity, T-C Jet Strainers cost far less than ordinary sand filters, yet they do an infinitely better job.

Got a water-flood in process . . . or planned? Let us send you full particulars on the T-C Jet Strainer. Write or wire:

THORNHILL-CRAVER CO.
P. O. BOX 1184 • HOUSTON, TEXAS

SELF-CLEANING
JET STRAINER

moisture problems with gases or liquids?

These economical CEC moisture measuring instruments deliver precise readings . . . immediate response. Available for delivery now!

All CEC Moisture Monitors and Accessories are fully guaranteed and backed by CEC's field service. The 26-301 and 26-302 monitors are absolute measuring devices. Both are highly portable for field use.

The 26-310, designed for continuous in-plant measurement of water vapor in process streams, assures precise regulation of sample flow under rugged process plant conditions. It is ideal for remote recording and control.

Custom designed monitoring systems . . .

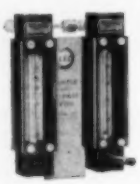
CEC's wide experience in the design and manufacture of moisture measuring devices enables thorough evaluation and specific handling of unusual or especially difficult moisture problems. For additional information, contact your nearby CEC sales and service office.

Type 26-301
PORTABLE MOISTURE MONITOR
Range: 1 to 1,000 ppm
Price: $650

Type 26-302
EXTENDED-RANGE MOISTURE MONITOR
Range: 1 to 20,000 ppm
Price: $750

Type 26-310
PROCESS MOISTURE MONITOR
Range: 1 to 1,000 ppm
Price: $1,420

Some of CEC's standard accessories that tailor basic models to specific applications . . .



SAMPLE BY-PASS *Cat. No. 26-011*
Indicates sample flow through the monitor, assures fast response of the external sample system. Price $70

BATTERY PACK *Cat. No. 26-012A*
Permits operation of portable monitors where line power is not available. Unit can be attached or removed quickly. Price $35

SAMPLE VAPORIZER *Cat. No. 26-013*
Enables monitor to measure moisture content of refrigerant gases or liquids and other similar gases and liquids. Price $260

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26-011 Sample By-Pass, 26-013 Sample Vaporizer, and 26-012A Battery Pack Accessories—Bulletin CEC 1848-X6.

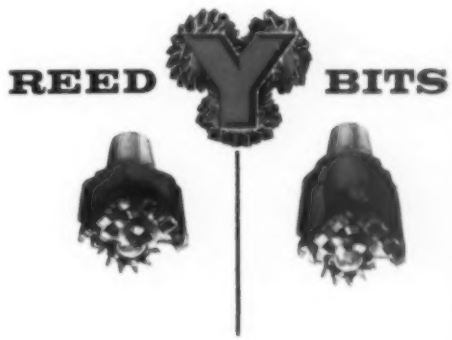
Here comes a good bit... and here's why

Reed Three Cone "Y" Bits are the latest developments in Reed's thirty-seven year history of designing and producing rock bits. The Reed "Y" Bit that is making hole for you today is the result of hundreds of thousands of man hours of research, engineering and technical effort spent by Reed Research and Engineering.

Reed research facilities are located in two large buildings at the Houston plant. They include complete metallurgical and chemical laboratories, mechanical testing apparatus, experimental heat treating facilities and an experimental machine shop. Laboratory drilling rigs that can apply loads of 100,000 lbs., at rotating speeds up to 500 rpm, with pump pressures to 5,000 psi, test full size bits on rock samples from all over the world.

Metallurgists, chemists, designers, engineers work as a team to develop a product that is produced to precise standards by skilled technicians in Reed's manufacturing plant. The compound benefit of *know-how* in design, development and manufacturing is a rock bit that is uniform in quality, bit after bit after bit.

Proved in the field for four years, the Reed "Y" Bit is the bit that will *dig*. You can't run a better bit.



Reed Roller Bit Company

Houston 1, Texas

19 GASO PUMPS FOR THE Four Corners Pipe Line

The pumps that move the crude from the gathering lines to the main line of the fifty-million dollar Four Corners Pipe Line are GASO Pumps. In all, Gaso has supplied the line with 19 pumps in models to meet the individual requirements at the feeder stations and in the Kingman and Corona pressure reducer stations. Typical feeder station installations:

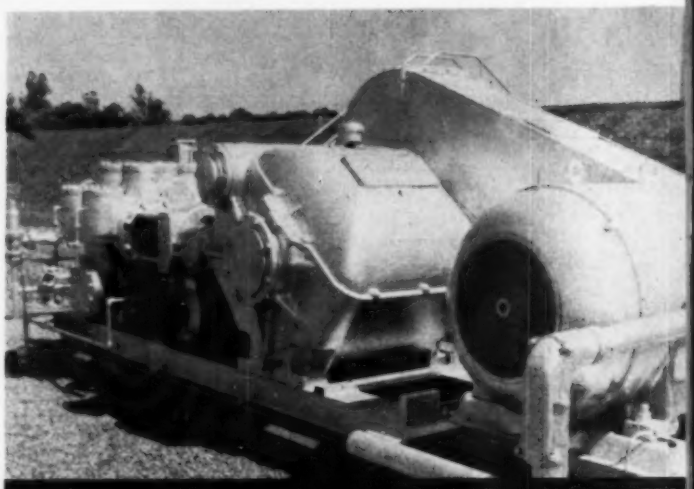
At Aneth: Figure 2652 Gaso Duplex Piston Power Pump (4" to 7¼" x 12").

At Arrowhead, Desert Creek, Rice, Little Mesa, Bluff, and East San Juan: Figure 1849 Gaso Duplex Piston Power Pumps (2½" to 4" x 10").

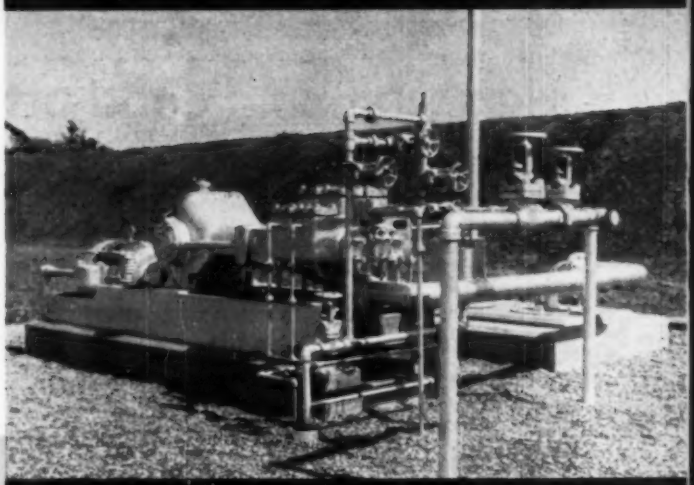
At Ratherford and White Mesa: Figure 1550 Gaso Duplex Piston Power Pumps (2½" to 5" x 10").

At McElmo Creek, Ratherford, San Juan, White Mesa, West Aneth and East Aneth: Figure 1753 Gaso Duplex Piston Power Pumps (4" to 7½" x 10").

The Gaso line includes many types and sizes of duplex piston and triplex plunger pumps with moly-iron, steel, and bronze fluid ends for handling crude oils, petroleum products, and salt waters under a wide range of capacity and pressure requirements. May we send you our latest catalog, just released?



Gaso Fig. 2652 Pump handling approximately 900 barrels per hour at the Corona pressure reducing station of the Four Corners Pipe Line. Powered by a 200 HP electric motor, operating at 78 RPM.



Another Four Corners installation: Fig. 2249 Gaso Duplex Piston Power Pump operated by 15 HP electric motor.

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NEW CONCEPT FOR ENGINEERING MANAGEMENT

"Management by Objective" replaces more intangible methods, sets definite goals and suggests reliable controls . . . A very concise technique that will appeal to the astute engineer

Howard P. Mold

A GREAT DEAL of the attention of any manager must of a necessity be devoted to the thousands of specifics and details, usually of a technical nature, which come to him for decision. Decisions on any one or all of these problems are too frequently made without reference to the fundamental objectives which the manager is responsible for accomplishing. The manager, of course, is responsible for "seeing to it that things get done" — whatever this means to the individual manager. This usually constitutes a fond hope rather that a specific working tool.

So somehow we must provide the manager with necessary, valid fundamental assumptions, principles or goals to use as standards against which to evaluate the validity and wisdom of his decisions.

There has been developed recently a new concept in management or we might better say, a better formulated concept, called Management by Objective. This concept is a very valuable tool to be used as a concept for decision making and parenthetically for *management development*.

Without defining at this point what we mean by "Management by Objective" let us proceed to an examination of some of its details and principles so we may better understand the definition later. A recent fine addition to the library of management books is a volume by Edward Schleh titled "Successful Executive Action." On page 4 Mr. Schleh says:

"Anything that is done in your company is worthless if no action results. But the action must be positive — action that improves the overall welfare of your company. Sometimes this is hard to get. In any company, you need push to get over the basic inertia that prevents action. Men seem inclined to let things stand. The status quo is comfortable. One of the biggest problems of an executive is to jar this comfort and get action. Sometimes the problem is to steer discussion over into action. Sometimes, many things are discussed, many problems are reviewed, but nothing happens. *An executive must find ways to get* all *discussions,* all *conferences,* all *contemplation into constructive action. To start with,* plan *for action. Very often we don't get action because we haven't met some of the basic requirements of action."*

Mr. Schleh in this statement has made it very clear that action will not result except that it be planned. So where do we start our planning?

Progress as a Goal

Most people if they were asked for their opinion of progress would undoubtedly say, "we must have it." America is the land of opportunity. We continually need improvements in our standard of living. Our defense forces cannot be trained and equipped to fight the last war. A business and industrial concern must have better manufacturing methods, better accounting methods, etc.

Now when we ask these same people what is progress, they find it difficult to define. Let us suggest a definition. *Progress is a change for the better.* Most people agree. But when we point out, in haste, that to have progress, an individual, a company or any organization must *change,* then we arrive at a parting of the ways.

The greatest number of people don't want to change. What they really want, are the benefits that flow from change without having themselves to change. Resistance to change is one of the most significant problems in any organization at any level and in any time period for it works against progress or improvement. There is no more important concept for a manager to understand and no more important area where he must have skill than in dealing with this very normal resistance to change.

Let us now discuss more specifically a manager's basic responsibility and see how this concept of resistance to change relates.

Fundamental Job of Manager

It is not difficult to get philosophical agreement that a company is in business to make a profit. It would then seem to flow naturally that a manager's job is to see to it that his organization makes a profit. However, management philosophers have recently pointed out to us that the two-fold job of a manager might be better stated as follows:

1. **To minimize losses, then maximize profits**
2. **To perpetuate the enterprise**

A careful examination of these two objectives makes clear that no organization can move into action on a new product line, the opening of a new factory, etc., and initially make money. As a matter of fact it seems quite obvious that in the beginning there will be many expenditures which are losses. The manager's job then is to see to it that the amount of the loss and the time period in which the loss is sustained are kept to an absolute minimum.

If this minimization of loss and maximization of profit is to be carried on, over a long time period, it means that the organization must be perpetuated and be kept healthy and growing. Generally an organization grows relative to the industry in which it finds itself. It is possible for any business organization to maintain its dollar volume and its same percent profit, and yet, when these are compared to the general industry and economic trends, they can actually be moving backward.

Perpetuation of the enterprise then becomes a major objective if profits are to be maintained in the future. This

objective, while really a part of the first objective, is stated separately because perpetuation of an enterprise is:

1. **So critical,**
2. **So difficult,**
3. **Takes place over a long period of time,**
4. **Probably will not happen unless carefully planned for.**

Few people in an organization are very happy about cooperating with programs of cost reduction and methods improvement. Similarly there are not many people in any organization who will voluntarily spend the necessary large amounts of time to improve their capacities to perform on higher level positions in the future.

Yet the manager *must see to it* that these things take place or his organization will make no progress. It is because the manager is so vitally concerned with the achievement of these two fundamental objectives that he must be concerned with resistance to change.

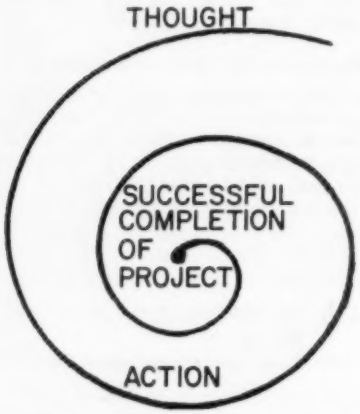


FIG. 1. A Definition of Management.

Definition of Management

Management has been described as a cycle of thought and action for the successful completion of any project. (See Fig. 1.)

Management may also be defined as *the direction of an activity*, usually involving people, for the successful achievement of pre-identified results. Both of these definitions are perfectly usable. If we carefully examine them we find that we can develop a major tool to provide the basis for managerial control of his operation. If we re-define the word thought as "planning" and the word action as "execution," then expand, we develop a new tool called a *management matrix*. (See Fig. 2.)

Management Functions

The seven functions which constitute planning and execution may be defined as follows:

1. **Planning.** Planning is the process by which objectives are identified and the details of "how" are spelled out. It provides for detailed descriptions of an effective means of accomplishment. Planning is divided into two parts — identification of objectives and programming.

(a) *Identification of objectives.* This is the process by which the overall responsibility of the manager is delineated into the individualized statements of what is to be accomplished. Each statement must begin with the word "to," must include an action verb describing what is to be done and must also identify results.

(b) *Programming.* Programming is the process of spelling out the means to be followed in the accomplishment of the objectives. Another way of putting it is that the objectives are the "what" and the programming is the "how." It frequently happens in the area of quota and sales program that the programming portion becomes objectives for some of the other areas.

2. **Execution.** Execution is the area of "doing" as opposed to the area of "planning." Execution as a management function may be divided into staffing, administration, coordination, supervision and evolution.

(c) *Staffing* is the process of identifying the amount and quality of manpower relative to the program described above. It spells out the manpower necessary to accomplish each individual portion of the program and is frequently described in terms of numbers of man hours to accomplish the given part of the program. It gives clues as to what types of training will be necessary and what kinds of personnel must be employed to accomplish the program and thus the objectives.

(d) *Administration.* Administration is the process of identifying those instructions, forms, accounting procedures, statistics and materials which are necessary to be used by the people identified in the staffing.

(e) *Coordination.* Coordination is the process of meshing the factors of people, materials and program into the proper time and place sequence so that the right activities are carried out by the right person at the right time. It also involves a notification of interested personnel whose activities may be affected by the carrying through of the program or whose cooperation, active support or interest may be required.

(f) *Supervision.* Supervision is not to be confused with work direction. Work direction is one facet of supervision and it is usually thought of only as the giving of instructions for specific portions of any work task. Most people in any organization are self-supervised, therefore, the process of supervision is essentially one of training of manpower and of exercising leader-

FIG. 2. Management Matrix.

Company Function Areas →	FINANCIAL 1	TECHNOLOGICAL 2	PRODUCTION 3	MARKETING 4	PERSONNEL 5	
PLANNING						
A. IDENTIFICATION OF OBJECTIVES	1	8	15	22	29	
B. PROGRAMMING	2	9	16	23	30	
EXECUTION						
C. STAFFING	3	10	17	24	31	
D. ADMINISTRATION	4	11	18	25	32	
E. COORDINATION	5	12	19	26	33	
F. SUPERVISION	6	13	20	27	34	
G. EVALUATION	7	14	21	28	35	

FIG. 3. Adaption of Top of Management Matrix to a Sales Organization.

MARKETING									PRODUCTION & PHYSICAL FACILITIES							PERSONNEL & ORGANIZATION							FINANCING & STATISTICS									ENGINEERING			
Marketing Research	Sales Program and Policy					Sales Promotion & Advertising																													
Territory Analysis	Forecasting	Territory Coverage	New Products	New Markets	Customer Training	Influence System Design (Customer level)	Advertising	Sales Promotion	Public Relations	Service & Repair	Manufacturing	Inventory	Housekeeping	Automobiles	Office Equipment	Space	Installation	Training	Organization	Selection	Assignments	Promotion	Compensation	Morale	Transfers	Pricing & Estimating	Quota	Profit	Direct Costs	Indirect Costs	Credit	Capital Expenditures	Donations	Budgets	Equipment Developments	Technical Data	Designing Systems	Control Applications

ship. Under this function the necessary training for the manpower identified under staffing is provided for.

(g) *Evaluation.* Evaluation is the process of comparing results achieved against objectives identified in 1 (a) above. Here the various tools and statistics developed in 2 (d) are used. Evaluation is not a process of measuring alone, but rather the process of comparing measured results against identified objectives. It should be emphasized that there is a sharp difference between evaluation and measurement. Measurement is the process of comparing something against the standard. Evaluation implies value judgment as to whether or not the results are satisfactory.

The company functional areas may be defined as follows:

1. **Financial.** All of those areas of an organization which relate to the general problem of the securing of monies, their control and dispersement. This includes such specific sub-areas as credit, budgets, accounting, etc.

2. **Technological.** All those areas of the company relating to its basic science or art. An advertising organization's technological area consists of the basic art of persuading people to points of view using verbal, written, pictorial and musical arts. The basic technological area of a company like Minneapolis-Honeywell is science and engineering.

3. **Production.** All those activities relating to the taking of the basic design developed by the technological area and converting it into saleable products, devices, components, etc.

4. **Marketing.** All those areas relating to the delivery of the product produced by the production area into consumers hands in exchange for monies. This includes such specifics as direct sales, advertising, market research, etc.

5. **Personnel.** Includes all those areas relating to the securing of manpower, its development and proper organization and utilization. This includes such specifics as recruiting, selection, manpower development, salary administration, etc.

Utilization of Matrix

The management matrix may be used as the table of contents for a planning book. The manager sits down and develops Chapter 1 by identifying all of the specific objectives in the financial areas.

His Chapter 2 consists of a detailed program, including time, as to how he is going to accomplish each of the specified objectives. When he has completed 1-7 he begins Chapter 8 with a specific identification of objectives in the technological area.

Obviously the structure of the basic matrix must be tailored to the needs of different organizations. Fig. 3 is an example of the conversion of a management matrix for the purposes of a sales organization. ■→

The Author

Howard P. Mold has spent most of his career in teaching management people how to do things easier and better. He has a broad background educationally — bachelor degrees in history and in chemistry from University of Minnesota. Later he received a master's degree in industrial psychology and became a Certified Industrial Engineer at Lake Placid Work Simplification School.

During World War II he attended the Command and General Staff school and in 1955, completed a year at St. Paul College of Law.

Present title of the author is manager of sales personnel department, Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota. He began his work with the company as director of training, a position he formerly held with Mead Corporation, Chillicothe, Ohio.

"Management by Objective" was presented before Western Petroleum Refiners Association, Wichita, Kansas, June 1958.

Control

Achievement of the specific objectives for any given time period as laid down in the management matrix must be related to the problem known as "control." The *problem* of control may be described as follows — "how can the responsible executive know at any given moment in time that each employee is doing his activities in such a way that when combined with the activities of all other employees — they will produce the objectives identified in the management plan."

In a negative way the problem can be identified as being even more critical. How can the responsible executive *know* at any given moment and time that each employee is *not* doing those things which will work *against* the achievement of the results.

In developing the solution we can use the following sequence.

1. **To control the manager must know what is going on.**
2. **To know what is going on he must have facts.**
3. **To have facts he must be able to measure.**

Anything less than measurement produces only estimates or opinions. This means then, that in order to accomplish the seventh management function — evaluation, the manager must have skill and willingness in the area of measurement. In this connection then an employee appraisal plan is nothing more than a tool to *measure* the performance of employees.

We can define control as the *process of making adjustments in the mechanisms for which you are responsible, within limits, in such a way, that preidentified results are accomplished.* Control implies, however, the control of people. A measuring system never can control an operation.

Most significant step in controlling an organization is the identification of objectives as discussed above. The second major step in exercising control is through the process of delegation. Delegation may be defined as *telling people what results they are to accomplish (in specifics) and the limits within which they can work.* If to these two steps we add a technique for upward reporting we accomplish about everything we can in the control of an organization.

There never will be, of course, any substitute for managerial judgment as to whether results observed fall far enough outside the limits established *to make it necessary to make adjustments.*

Definition

Management by Objective as a concept may be stated "if a manager cannot and does not in advance of the time required for action, spell out his objectives in writing in great detail he does not know for certain what he is doing." As a consequence there can be little hope that his operation will achieve the necessary results so that fundamental objectives of the organization will be accomplished. Management by objective requires the following steps.

1. **Putting in writing, by functional area, the objectives to be accomplished** *in terms of results.*
2. **Laying out a preliminary program for each objective.**
3. **Securing approval of the manager's superior.**
4. **Communicating these objectives to subordinates for their detailed programming.**
5. **Defining the limits within which the subordinates can operate.**
6. **Defining the necessary evaluation devices so that the manager will be able to determine periodically what are trends for accomplishment.**

Management by objective provides every manager in every kind of operation with necessary specific tools and concepts for direction and control of his operation. * * *

How Not to Forecast

Crawford H. Greenewalt

ERRORS ON THE SHAPE of things to come have been due in large measure to the fact that the forecasters reasoned from the framework of the science and technology of their own times and could not take into account the revolutionary effects of the basic new discoveries which lay just over the horizon. I will mention only two instances: Thomas Jefferson, in announcing the Louisiana Purchase, felt that the territory might be fully occupied after 25 generations; i.e., along about 2600 A.D. He could not have foreseen that the invention of the railroad and the steamboat would bring settlement within a few decades.

You may recall also that Sir William Crookes, in 1898, foretold imminent starvation for the human race through diminishing supplies of nitrogen. From the point of view of the technology of the day, his was a perfectly valid prediction, but what he could not foresee was that chemistry and chemical engineering, through the fixation of nitrogen from the air would, within a generation, thrust the threat of starvation far back into the future.

I must say that the science-fiction writers of the early days have a much better score than the scientists. Jules Verne did anticipate the submarine and, in his amusing story of a trip to the moon, he also prophesied a Sputnik of sorts. But even his vivid imagination did not foresee the airplane or the radio or television or the host of new things that we look upon today as commonplace.

On balance, I think if I were to be forced into prophecy, I would be disposed to ignore sober scientific judgments, however eminent, and use as my text the last few issues of "Space Merchants" or "Galaxy" or "Astounding Science Fiction."

I once tried to come to grips with an acceptable forecasting alternative by reviewing those human needs as yet unfilled. But here, of course, we encounter the same difficulty; in only slightly different guise, it is the old question of the egg or the hen. I doubt very much that many of today's marvels were developed wholly out of need. I think, rather, that our need for new things was realized only after we saw what could be had.

We fly in airplanes today not because we thought we needed that kind of transportation, but because two men, motivated largely by scientific curiosity, proved it could be done. I expect the same thing could be said of the automobile, the washing machine, and even such minor boons to womankind as the Toni which, my spouse informs me, is a home permanent.

It is a fortunate circumstance that we do not have to visualize the precise shape of things to come to be able to predict with confidence many more decades of growth and prosperity, and, of course, of opportunities. The past provides us with broad indications which are both sound and reliable, for as long as man's curiosity persists and the incentives to progress are provided, the scientific horizons will continue to recede, our material benefits will continue to increase, and any human needs that we are able to define will one day be met.

Mr. Greenewalt, president, E. I. duPont de Nemours and Company, made these observations in a speech before the American Institute of Chemical Engineers at Philadelphia, June 25, 1958. Name of paper was "Human Achievement and the Free Society."

The Future for Oil

Here is an interesting analysis of oil needs in the United Kingdom in 1970. The same factors apply to other areas. . . including the contribution of nuclear energy. The author believes demand will double — could treble

Sir Neville Gass, K.B.E., M.C.

The author, Sir Neville A. Gass, became chairman of The British Petroleum Company February 1, 1957. Born in 1893, he was educated at Tonbridge School and McGill University, Montreal.

During the 1914-18 war he held a commission in the Royal Artillery, being awarded the Military Cross and the Belgian Croix de Guerre.

In 1919 he joined Anglo-Persian Oil Company (as The British Petroleum Company was then named) and served in Persia until 1934, latterly as deputy general manager. In 1934 he was transferred to the London office, and has been a managing director of the company since 1939, being appointed deputy chairman in April 1956.

He was created a Knight Commander of the Order of the British Empire in 1958.

THE UNITED KINGDOM is one of the key centers of the international oil industry. It is a leading consumer of oil products with large modern refineries catering for home consumption and a considerable export market.

It has also, through the activities of British oil and shipping companies, a very large investment in the worldwide operations of the oil industry. And behind this direct participation a substantial part of the country's industry is engaged in supplying the wide range of plant and equipment and materials necessary to produce, process and transport oil, and in manufacturing the even greater variety of engines and machinery which consume oil products of different sorts.

It is clearly to the advantage of the United Kingdom to maintain and expand its participation in the oil industry, not only from the point of view of supplies of energy for the future but also to take full advantage of the benefits of the coming technological age.

Coal and Nuclear Energy

A forecast of total oil demand in the United Kingdom in 1970 rests upon important assumptions about the level of economic activity by that time and of the availability of coal and nuclear energy. Economic progress must be assumed and its continuation at the average post-war rate seems reasonable in the light of the increased productivity that should arise from the country's capital expansion. An assessment of the availability of coal and nuclear energy can only be approximate.

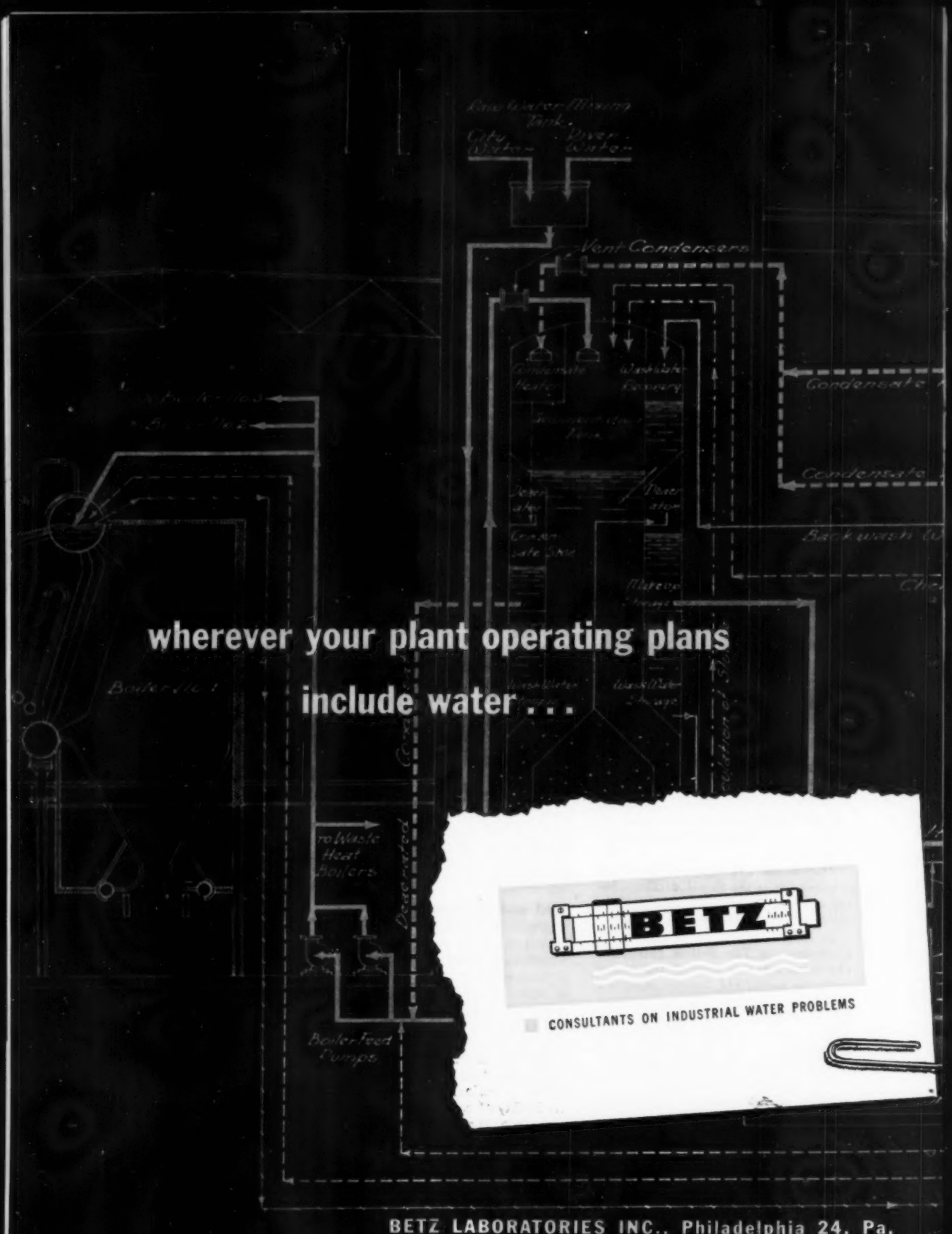
If the Coal Board's plan is accepted and a realistic expansion assumed in nuclear power stations, then on the basis of reasonable progress in our economic activity the overall demand for oil in Great Britain is likely in 1970 to be at least double that of today.

In many other parts of the world the factors which determine the demand for oil are operating more forcefully and an even greater rate of increase in demand is to be expected. Thus the oil industry in the free world may well be faced with a demand for its products rising between now and 1970 by more than 100 percent. This is a tremendous growth to cater for and one of considerable potential impact on the British economy.

Within this total demand for oil, changes in the pattern of products required will also take place. These will mainly arise from developments in the methods of converting the energy in oil into useful work. Some of the factors in this direction are already apparent, others depend on the success of research within and without the oil industry. Changes in the pattern could also be brought about by adjustments of taxation on different petroleum products.

Among the factors that are apparent is the increasing proportion of high compression ratio engines in the world's car population. This will lead to a strong demand for very high-octane motor spirits and a slowing down in the demand for lower grades. The greater number of jet-engined civilian aircraft will increase the demand for a fuel different from the special aviation spirit required for the piston-engined aircraft. Another factor is the dieselization of railways, and the certain continuation of the existing trend toward the use of the diesel engine in commercial road vehicles and in farm tractors, which will mean an increase in demand for gas oil.

By 1970 the problem of adapting the jet engine for road use may be solved, at least for heavy goods vehicles, leading to the introduction of a power unit which can use a wide range of fuels.



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Special Technical Advantages

As nuclear energy becomes increasingly available, this should ease the pressure of demand for both coal and heavy fuel oil used for electricity generation. But a large market will remain for oil products for industrial, commercial and domestic heating and for industrial processes and power. Where it has special technical advantages oil-firing will continue to be chosen by the consumer.

Here it is necessary to emphasize that the future level of demand for heating oils being dependent upon economic activity and living standards as well as upon the development of nuclear power and the coal industry, only a small change in the assumptions could give a very different picture.

For example, total oil demand in the United Kingdom in 1970 could be treble — not double — today's consumption if only a marginally higher degree of economic activity coupled with a slightly lower output of coal (whose importance to our national economy is such that it is to be hoped that there will be no such reduction) and nuclear power is assumed.

To all these factors must be added the increasing demands by many industries for petroleum for further processing. Among these are the demand by the gas industry for oil for gasification and the special needs of the petroleum chemical industry. These two requirements are likely to become an increasingly significant item in the future United Kingdom refinery output.

Changing Pattern of Demand

The oil industry has always been faced with a changing pattern of product demand. But the tempo of change looks like accelerating in the environment of rapid technological progress in the years ahead. Refining operations will become more complex and refining methods and economics will face a real challenge.

Such a challenge will, as in the past, be successfully met because the refining of crude oil into marketable products is among the most advanced industrial processes in existence. In this branch of the oil industry extensive laboratory research, continually widening the frontiers of knowledge in many branches of applied science, goes hand in hand with the practical full-scale application of new techniques discovered.

The remarkable adaptability of the oil industry is the result of heavy and fruitful investment for many decades in research and the future will see this policy continued, ensuring the development of the new or improved products that will be in demand and of the processes necessary to give full refinery flexibility. In this sphere an important new tool of research is in the use of radio-isotopes.

Rapid progress can be expected in the application of automation in petroleum refining, not only in the operation of the individual process plants through improved automatic analysis and control instruments but to the refinery as a whole. A great deal has been done in this respect already, but the use of the computer combined with other developments in electronics will result not only in improved control of processing but also facilitate smooth changes in the pattern of product yields. Considerable advances are expected too in the coordination of programs for a group of refineries to provide the most efficient operating schedules.

Increasing demand for petroleum-based raw material for the chemical industry foreseen in the near future has already been mentioned. In the growing petrochemical industry base materials for synthetic rubbers, resins, emulsion paints, detergents, fibers, fertilizers and plastics and produced from oil. Here, too, research is intense and not only will many new processes be found but new materials may be expected to be discovered. Such development will depend to a large extent on a vigorous domestic oil-refining industry which will ensure the supply of products for further processing in a wide range of other industries.

Location of New Capacity

This will be one of the factors in deciding the location of new refining capacity in Britain. Plans for substantial new capacity have already been announced but even more than this will be required by 1970. The petrochemical industry, the supply of oil and gas-making and developments in transportation facilities are among the factors which will determine the location of new capacity. Major crude-oil terminals will be increasingly located where deep-water ports can be created to receive the very large tankers. This is demonstrated by projects recently announced to develop a number of British ports.

As with most major oil-consuming areas, except the USA and USSR, the United Kingdom relies upon imports for the bulk of its crude oil supplies.

Ample reserves of crude oil have already been proved to support all likely world demands far beyond 1970. Some two-thirds of these reserves are in the Middle East and, unless large new fields are discovered elsewhere, world demand will be met here most easily. But the worldwide search for new oil production is now so intensive that by 1970 the existing range of alternative supply sources may have been substantially expanded. Unfortunately prospects in the United Kingdom itself are not promising. However, more important fields have been discovered elsewhere in Europe and recently there have been promising new discoveries in the Americas and North and West Africa, while in both the Eastern and Western Hemispheres there are still vast untested areas.

Under-Water Drilling Techniques

Continuing progress can be expected in the next 12 years in the tools used in searching for and developing new sources of crude oil. The techniques of under-water drilling should show a pronounced development during that period, thus bringing within the scope of oilfield exploitation considerable areas of the world's continental shelf which only a few years ago could not be tested or developed commercially. Consequent increases in world reserves should be substantial by 1970.

Research work is also being directed to means of increasing the yield of oil fields by secondary recovery. The normal production methods of today extract only a fraction of the oil in place. In most fields considerably less than 50 percent of the oil originally in the underground reservoirs is at present producible. To raise this percentage will be as effective as the discovery of many new fields.

Apart from deposits of liquid petroleum there exist vast reserves of oil shale in the United States and elsewhere from which petroleum products can be manufactured. There are also deposits of very heavy oils or bitumens which are capable of yielding most of the normal petroleum products in greater or lesser proportion. The greatest of these deposits, the Athabasca tar sands of western Canada, is estimated to contain a total quantity of such bituminous matter comparable in magnitude with the present proved recoverable crude oil reserves of the Middle East.

Research is being directed to the development of these solid and semi-solid sources of hydrocarbons, and 1970 may see substantial supplies of oil being produced from them.

Long-Distance Transport

In speculating about the availability of oil in 1970 many unpredictable factors are evident, but it is safe to say that there will be adequate raw material available to meet any possible demand for petroleum products. The Middle East is likely to be the largest source of supply provided stable trade conditions prevail there, but if for any reason its

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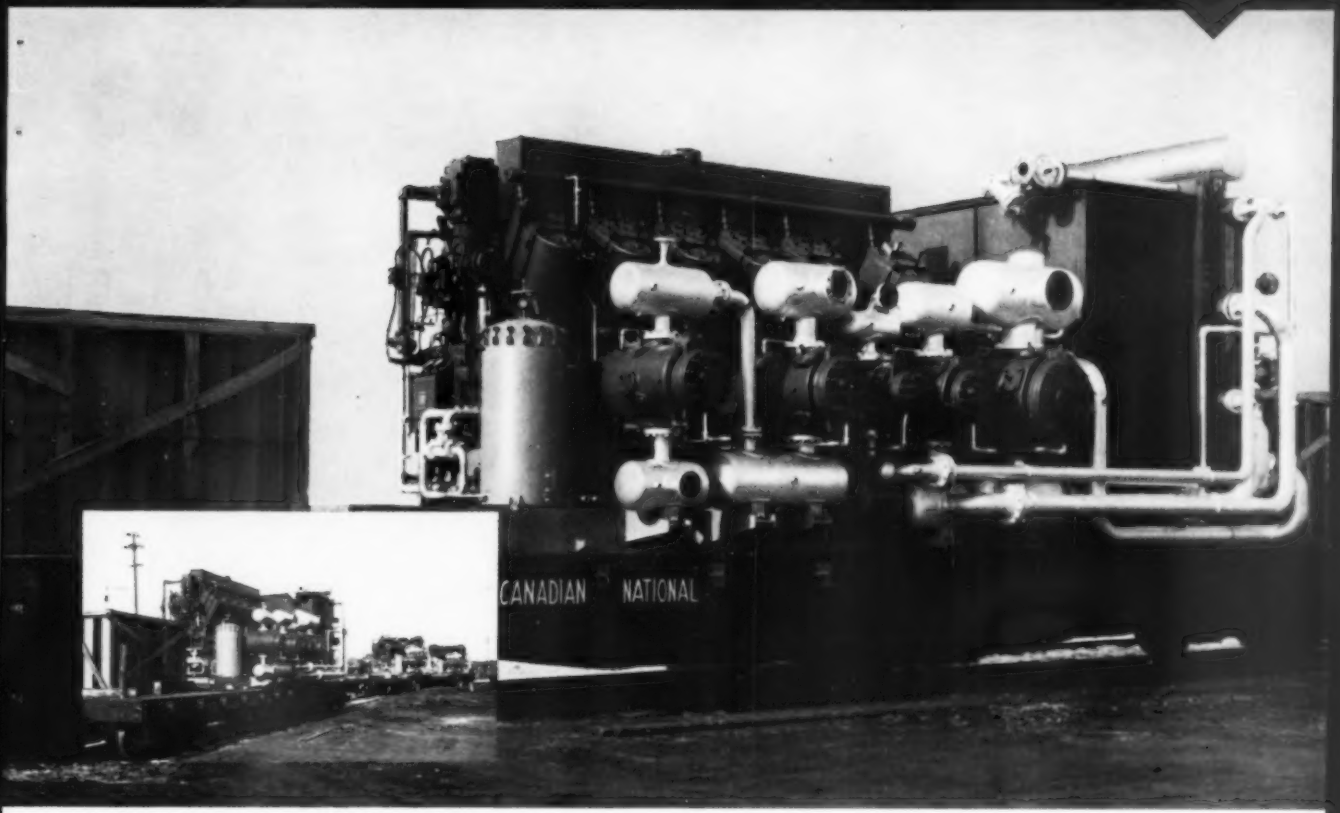

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supplies were interrupted or diminished it is also likely that world demand for petroleum products could be met from alternative sources, though at increased cost.

The transport of oil from well to consumer is one of the most important phases of the industry. It has been calculated that, on an average 10 times more transportation is involved in delivering oil that in delivering coal. This is due to the great distances through which oil must be moved from the U. S. Gulf, Caribbean and Middle East areas to the main demand centers which are principally in the heavily populated industralized areas of the world.

The two main methods of moving oil in bulk, by pipeline and tanker, are generally complimentary, not competitive. Pipelines are necessary to carry oil from the fields to seaboard and some, such as those serving the land-locked fields in North Iraq and Canada, represent an enormous fixed investment. But generally the most economic way of moving oil thereafter is by tanker although, with expanding demand, pipelines will be increasingly used to carry crude oil and products into inland markets from receiving ports in consuming countries.

In some areas a long sea voyage can be shortened by a pipeline and if the quantity of oil to be carried is large the pipeline becomes an alternative. The choice is then mainly a question of the risk involved in the two forms of capital investment.

In order to supply the world's future oil requirements many new pipelines will need to be built and given stable operating conditions some of these will undoubtedly augment the existing Persian Gulf/Mediterranean pipeline systems. Since most of the world's oil supply has to move by sea on some part of its journey the world's tanker fleet will need to be considerably enlarged irrespective of pipeline developments.

In the last 10 years a complete change in the conception of the upper limits of economic tanker size has been seen and orders for new tankers in hand and still to come will ensure that ships with a carrying capacity of 60,000 to 70,000 tons will be quite common by 1970, while some with even greater capacities ranging up to at least the region of 100,000 tons will also be in service.

At present utilization of very large tankers is restricted by physical limitations of depth of water at loading and receiving terminals. But in the principal oil supply and consuming centers deep water loading and discharging terminals with adequate facilities are likely to be made available to cope with the very large ships before they could be built in any numbers.

Allied to tanker developments are the pilot plant experiments in the sea transportation of natural gas. Some technical problems have still to be solved in the handling and storing of a normally gaseous material held in liquid state by refrigeration at the very low temperature of −250 F. But a main problem of research is to discover a means of transportation which will give a delivered cost of natural gas in consuming areas competitive with other fuels. The solution of these problems would add considerably to the reserves of hydrocarbon fuels which can enter into international trade.

Considerable development will take place in the equally important transport task of distributing products from refineries and bulk installations into the market. Intensive study will continue into the most economic way of effecting delivery and there will be much scope for experiment and operational research into the most effective use of road, rail, sea, river, canal and pipeline transport. In this field the availability of electronic computers will assist in achieving optimum conditions.

Personnel Needs

A major difficulty which will face the oil industry in the coming years will be the recruitment of personnel. The need for more research, added complexities in refining, automation and program coordination will require a higher proportion of specially trained personnel with sound scientific knowledge and skilled engineering ability for duty throughout the world. In this respect the oil industry will be in keen competition with other industries for behind this forecast of intensive development of the oil industry lie fundamental assumptions of expansion in other spheres where technical ability will also be at a premium.

New Demands

Growing oil demand means new consuming machinery – airoplanes, road vehicles, ships, trains, tractors, and oil burners of every description. New chemical works will be built to process oil products into other materials, which in turn will be manufactured in other factories into consumer goods.

The oil industry itself will be an increasingly important customer for oil field, refinery and transport plant and vehicles and also all the ancillary electrical, electronic and other equipment which will be necessary in an industry in which automation will steadily advance.

More cars, lorries and buses on the roads will make it imperative that our road system should be further improved for the smooth flow of increasing traffic. New roads will be necessary and convenient parking space and garage accommodation will have to be provided.

All these inter-related developments cover a wide range of economic activity and 1970 will see the oil industry ranged in the forefront of those major industries on which our industrial society is based. ★ ★ ★

This was first published in The Financial Times March 3, 1958.

PROFIT MARGIN NARROWS

Lowest assets in 20 years were reached in 1942 . . . percentage return in 1957 lowest since 1949

Because The First National City Bank of New York does such an extensive survey on income of petroleum companies we have reproduced here its survey results since 1937.

During the 30's the industry lived off its assets, coming to its lowest investment in 1942. It wasn't until after World War II, when the expected slump in demand did not materialize, that the industry pushed for vital income margins. Much of the petroleum industry's capital expenditures are raised by undivided profits.

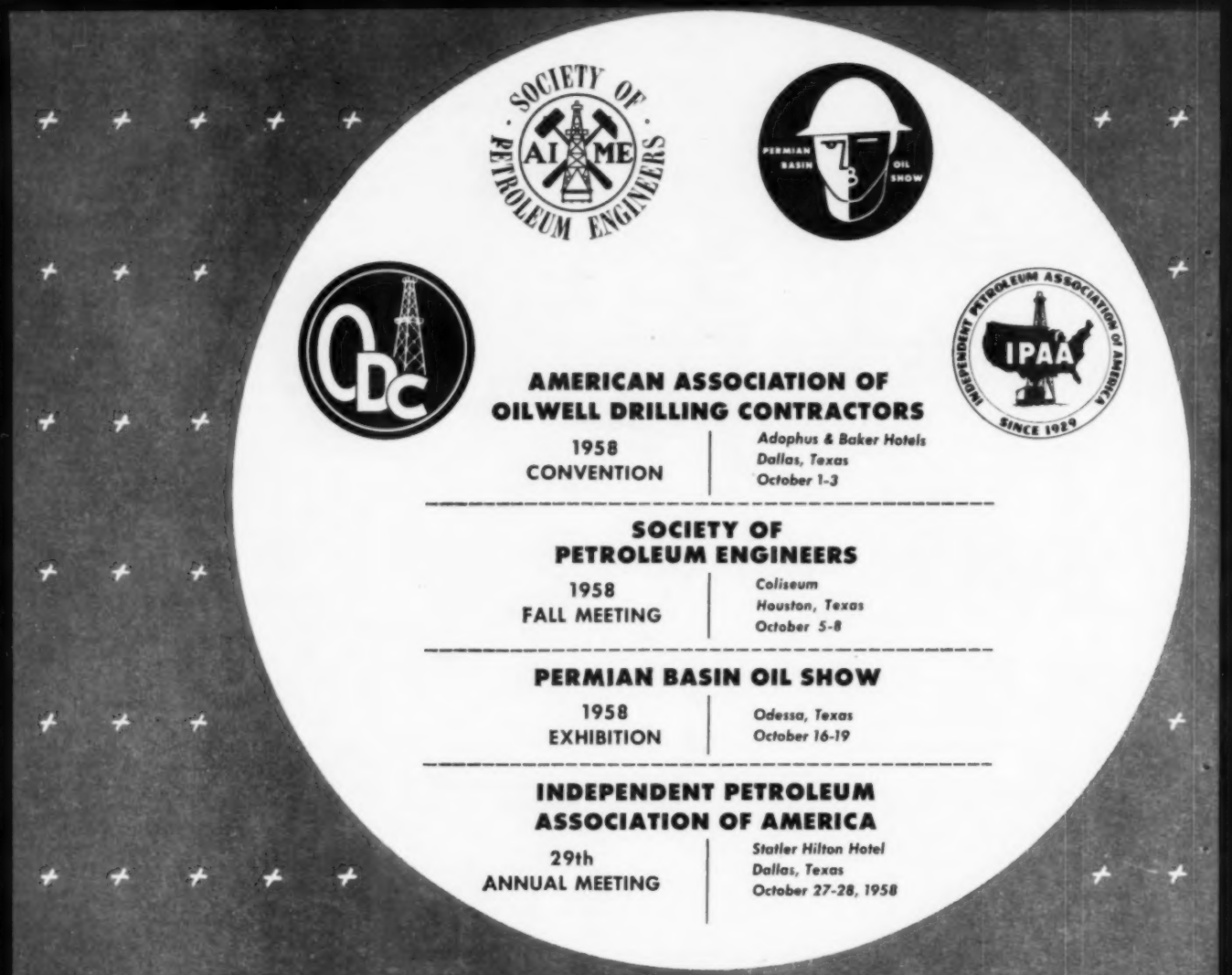
The narrowing margin of earnings has been accompanied by selling bonds, debentures, and stock for high capital required in the petroleum industry.

In the 67 oil companies covered by our annual report survey (May 1958) percent return on net worth came to 11.7 percent, lower than the figure here of 13.6 for 116 companies.

Net Income After Taxes of Leading Petroleum Producing and Refining Companies.

(In thousands of dollars)

Year	No. of cos.	Net income	Net assets Jan. 1	% return
1937	93	491,821	4,919,673	10.0
1938	93	266,240	5,206,860	5.1
1939	80	235,759	4,401,854	5.4
1940	82	264,695	4,987,677	5.3
1941	78	485,368	4,930,853	9.8
1942	81	283,555	3,965,834	7.1
1943	77	314,004	3,876,436	8.1
1944	82	655,833	6,690,892	9.8
1945	77	483,157	5,594,588	8.6
1946	84	797,096	7,381,123	10.8
1947	81	1,285,930	8,064,518	15.9
1948	88	2,098,028	9,244,793	22.7
1949	84	1,528,577	11,257,521	13.6
1950	91	1,875,150	12,346,685	15.2
1951	91	2,262,028	13,532,439	16.7
1952	91	2,172,405	14,998,992	14.5
1953	95	2,362,140	16,402,291	14.4
1954	94	2,456,233	17,731,128	13.9
1955	92	2,770,552	19,488,977	14.2
1956	101	3,144,822	21,451,503	14.7
1957	116	3,239,562	23,811,998	13.6



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DRESSER DYNAMICS, INC., Northridge, Calif.—Advanced scientific research. Development of new types of instrumentations and testing in the fields of missiles and propellants.

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the Petroleum Engineer
FOR MANAGEMENT

Economic Training in

Fast-growing Junior Achievement provides "learning by doing" for thousands of high school students. Petroleum companies take an active part as advisers to firms run by teen-agers

After the officers had been chosen and the product to be manufactured decided upon, the company issued non-legal, non-transferrable stock with a par value of 50 cents. Here, the treasurer of "WoodCo," Winona Whitwell, is selling a share of stock to the president of Oil Well Supply Division of U. S. Steel.

THIS FALL some 3900 new corporations have been formed in the United States. During September and October 65,000 security salesmen, none of whom has reached his 19th birthday, will market over 800,000 shares of common stock to finance these new companies.

This economic activity will not change any business indices nor will it indicate a Fall upturn in business. But it does auger well for the economic future of America. For these new corporations will be Junior Achievement companies, formed and operated by teen-age high school students as part of the Junior Achievement program of economic education.

Of the 3433 miniature businesses operated in the United States during the past year, over 150 were counselled by firms in the petroleum industry.

These Junior Achievement companies are of vital importance to the petroleum industry. They provide the business community with an impressive vehicle to tell the story of private enterprise to youth and through youth to the nation.

The "learn-by-doing" program is a nation-wide, educational organization which offers young people of high school age the opportunity to gain valuable and practical pre-business experience by organizing and operating their own small-scale businesses with the guidance of volunteer advisers from business and industry.

Each JA company is counselled by an adult business organization and advised by three employees of the counselling firm.

Starting early in the Fall the 15-odd members of each JA company decide on the product they wish to produce or the service they wish to render, elect their own officers and capitalize their miniature business by selling stock at 50 cents a share. Average capitalization is about $100.

With their capital they buy raw materials, pay themselves wages (each youngster is both a member of the board of directors and a member of the labor force) and pay rent for working space.

They manufacture their product, determine sales plans; and hit the street to sell door-to-door. They keep complete books and records and in May wind up their business affairs by returning capital stock and paying a dividend, if earned.

The experience of the Handi-Home Products Company counselled by The Humble Oil Company in New Orleans is typical of problems faced by JA enterprises.

The first problem which faced Handi-Home was selection of a product to be manufactured. After a good deal of discussion and research it was decided that a market existed in the area for aluminum stools.

Materials were purchased for construction and immediately bugs in the production line developed. The young people found it necessary to design and build various jigs and bending fixtures.

When production was reasonably under control they discovered a quality control problem. The stools were coming off the production line with the legs coated with scale and dirt. A quality control section was set up and a new step in the production line was attempted. Each product coming off the production line was scrubbed down with steel wool. The youngsters found this hand finishing, although laborious, added greatly to the appeal of their product. The teen-agers thought that now that production was running smoothly they "had it made." Not so.

With limited capitalization the capital position deteriorated rapidly. To

Action

Sales Adviser Art Tilston of Union Oil of California discusses sales problems with the sales manager of the Union Oil-counselled Hangco Company. The Los Angeles J. A. company is one of hundreds counselled by petroleum firms.

combat this situation rigid material control procedures were developed and a production schedule and program went into effect. This helped them keep raw material purchases to a minimum, thus preserving their precious capital.

Initially sales were no problem but soon the built-in supply of parents and friendly neighbors ran out and sales techniques came to the fore. After each work session the teen-age sales manager held a "rah rah" type sales meeting. A small brochure entitled "Sales Tips" was developed and given to each salesman. Posters advertising their product were developed.

A special sales drive was set in motion during the Mardi Gras season in the belief that the many parades in New Orleans at that time of year would provide a ready-made market for the light-weight stools. This proved so successful that the young people alerted the sales to other opportunities and sales pushes were developed for golf tournaments and the opening of swimming pools.

With rapid increases in production techniques productivity was increased and wages raised. At the conclusion of the school year this Humble counselled miniature business had grossed almost $2000 at the time of its liquidation in May and its 21 enthusiastic young people had taken the long step toward a clear understanding of the American system of private enterprise.

Because JA companies are regular business they have to face the same type of problems which confront adult enterprises.

The Sojac Novelty Company of Youngstown, Ohio, counselled by the Standard Oil Company (Ohio) were manufacturing a Knick-Knack shelf. Production problems plagued the group. Working capital was disappearing fast. The youthful directors of the Sojac Novelty Company saw that unless capital was pumped into the business one minor set back could bankrupt the enterprise.

Shown here is a part of the production line of Handi-Home Products Company of New Orleans, counselled by Humble Oil Company. Product was aluminum stools, and bugs in manufacture had to be removed.

The solution was one which has helped many adult businesses – diversification. The young people became jobbers for ash trays and candy dishes. These proved hot sellers and vital capital was pumped back into the company. In the meantime a crack crew of the best production people worked out the bugs in their Knick-Knack shelf and the company was on its way to a successful year.

In another case, the WoodCo Company, counselled by Oil Well Supply Division of U.S. Steel, Dallas, Texas, was manufacturing a wooden cutting board for the kitchen. The cutting board proved such a hot seller during the Christmas season that sales were rapidly out-pacing production with the problem of losing sales because of delayed deliveries. The young people hit on special gift certificates as a solution. The gift certificates were sold with the notation that delivery would be made after the holidays. The plan caught on and sales were doubled.

Some of the lessons learned from adversity do not have a happy and profitable financial lesson. The Hangco Company, counselled by Union Oil of California in Los Angeles, engaged in the manufacture of a hanging redwood basket. Managerial problems were encountered which might have licked a

Redwood hanging baskets are given careful examination before being passed by the quality control section of the Hangco Company, counselled by Union Oil of California.

Typical of the problems faced by J. A. companies is slumping sales. Sales clinics demonstrate sales techniques. Here the achievers of JAGCO, counselled by Gulf Oil Corporation in Pittsburgh, evaluate each other's sales "pitch."

"senior" concern. Key officers resigned. Several errors in designing production layouts ran the cost on the first basket off the assembly line up to the astronomical figure of $125—almost the entire capital of the little company!

Man and nature also ganged up to cause headaches. The Hawthorne JA Business Center was entirely remodeled (which made better facilities eventually but didn't help the kids in Hangco at the time), and unseasonal rains, which shut down many major Los Angeles plants, hampered production when the power to run machinery failed. In spite of these handicaps, Hangco ran up sales of $166.39.

The kids will pay back stockholders (225 at 50 cents a share), but no dividends will be declared. President Mike Benjamin, 17-year-old Washington High School junior, regrets this but is proud that no investor will lose money. Optimistically, like any good business executive, Mike is sure that "given a little more time I know we would have made a substantial profit," and then adds philosophically, "at least now we know why we didn't."

According to Mike, the "why" means planning, product design and foresight. "Now," says Mike, referring to Junior Achievement members, "is the time to make mistakes, when it doesn't mean too much, rather than when it means where your next meal is coming from."

Individual members of JA companies counselled by firms in the petroleum industry have had many outstanding successes. During the past year Nancy Kay Simpson, 17, of Oakland, California, was named Junior Achievement's "best salesman for 1958." Nancy's company was counselled by Standard Oil of California.

Junior Achievement* began in 1919 in Springfield, Massachusetts, when the late Horace A. Moses, then president of the Strathmore Paper Company, put into action his feeling that urban youngsters could profit from a "learn-by-doing" program like that of 4-H Clubs. It was incorporated in Massachusetts in 1926.

Petroleum executives have played a major role in the remarkable post war growth of Junior Achievement. M. J. Rathbone, president of Jersey Standard has been a member of Junior Achievement's national executive committee for many years and from 1955 to 1957 headed the national development campaign. Rathbone says this: "In Junior Achievement young people learn early how important it is to business and personal success to be willing to work, to maintain an undeviating personal integrity and to respect the views and rights of others."

Henry J. Voorhies, vice president of Esso Standard and general manager of Esso's Baton Rouge refinery, spearheaded the development of JA in the Baton Rouge area. From his three years of close observation, Voorhies says: "My past few years of activity in Junior Achievement have convinced me of the tremendous value of this program. With the great wealth of misinformation about business in circulation today, American industry has a positive need and the responsibility of telling its own story — to sell itself. Junior Achievement gives to business a truly effective means of communicating the facts about free enterprise. It is economic education in action."

In Pittsburgh Gulf Oil has been active in JA for nine years. W. L. Naylor, senior vice president, sums up his company's years of experience in these words: "Junior Achievement has received Gulf's support primarily because of the splendid educational work it does in teaching the true merits of the American free enterprise system to high school students in our area. A by-product of this effort is the public relations benefits that the enthusiastic young Achievers generate by their attachment to the 'big company' which helped make their program possible.

"For these reasons, we believe that Junior Achievement exerts a worthwhile influence in the community by helping our future citizens obtain a better understanding of the American way of doing business as well as building good-will in the community."

To sum up, Junior Achievement offers many advantages to business.

First, there is the institutional benefit of thousands of young Americans learning the problems and rewards of our free enterprise system.

Second, Junior Achievement provides an effective community relations program. By means of this contact with youth the corporation becomes personified to its community and gets additional opportunities for favorable publicity.

Finally, adult advisers find Junior Achievement a valuable training program. Working with inquiring young minds is a real opportunity to test and practice leadership. ★ ★ ★

*To get more information on Junior Achievement petroleum executives are invited to call their local J. A. office or write Junior Achievement, Inc., National Headquarters, 500 Fifth Avenue, New York 36, New York.

Only the Petroleum Industry Can Act

Congressman Harris (D. Ark.) has courageously backed freedom from Federal controls for natural gas producers. Each bill for decontrol has more regulation — the Kerr bill, the Harris-Fulbright, and now the bill Harris proposes, which is not decontrol at all but a more practical control of gas production.

Our friends in Congress grow increasingly frustrated because of the industry's unsatisfactory public relations. Vetoes of two Presidents of gas decontrol have been popular largely because of the industry's unpopularity.

In the excerpt below of Congressman Harris' speech to the Panhandle Producers and Royalty Owners Association in Amarillo, Texas, he pleads for a more reasonable, a more consistent approach to industry's problems.

The petroleum industry has bitter, determined enemies who want nothing less than overall government control. We make it too hard for our friends to help us fight for freedom to work and to supply our nation with its most useful energy.

Look above your valves and your rotary tables and your desks if you would see the dangers we face.

Congressman Harris tells it straight. He has said many times what he mentions below — that unless the industry reaches a common ground to fight for freedom from controls, the battle is lost and victory for the opposition means a private industry cannot survive.

OREN HARRIS, *Member of Congress*

IN ALL CANDOR, you have been on trial before. To date I must say you haven't been doing too well for the last few years.

Let me suggest two or three things for your consideration. Perhaps some fundamental questions deserve careful consideration and frank and honest answers.

Has the fuels industry become so highly competitive and self-centered that it breeds mostly frustration, envy and strife within? Has competition been blown up until it threatens the inherent principles under our American system and the service demanded by the American public? Healthy and vigorous competition strengthens this system we know. But we must recognize that it is also through unity and coordination and understanding that these principles prevail.

Quit Infighting

Within your industry, within the entire fuels industry, it is important to discontinue the infighting and to work together toward legislative policy so obviously in the interest of our total economy.

Furthermore, have you in the industry told your story fully and fairly to the American people?

Have you made known the facts — all the facts — about your operation?

Have you across the board been willing to stand up and meet the issue and battle it out in the good old American way with those, your enemy in principle, that would destroy or seriously hamper your future and the service that you can perform to the American public?

Or have you been letting internecine warfare create in the public mind an image of this great industry as a collection of self-seekers who have no regard for the public welfare?

You have a story to tell — a service to provide — a fundamental principle to preserve — a strong and effective industry and organization if unity of purpose on fundamentals can be reached.

You see, we are on the receiving end of your letters and your testimony on matters that concern the industry. We honestly find it most difficult at times to tell where the truth lies when royalty owners are pitted against producers, or producers against refiners, or refiners against jobbers, etc.

The Common Ground

Finally, isn't there a common ground on which a great industry as is yours and the fuels industry can unite on principle — the common ground that is the welfare of the general public?

On this basis there should be unity. This should be the paramount concern. Otherwise, I am frank to say, we are going to see a great industry hard put to its survival, much less to prosper. We should remember and act on the solid adage that "there is no true profit in anything that results in a public loss."

My years of experience in Washington have convinced me that the oil and gas industry must undertake and pursue a sound course on this common ground and present facts and a fair interpretation of them.

I believe that the industry has an obligation to the public and to the government to improve its public relations.

The opposition is working steadily and skillfully. Make no mistake about it. The need for giving the true and factual story is acute. Even while you sit here today, the net of a strangling regulation draws more tightly around you.

Freedom Support Weakens

We must remember that in this long drawn out problem that at every step of the way, support for the cause of freedom has grown weaker.

The formula for success in combating this trend is quite simple: All that is needed is to present the facts fearlessly and fairly in combating vicious propaganda and then stand together for the common welfare, working together for a finer national economy. You will gain by it. Your children will gain by it. We will all have a greater and more prosperous future. ★ ★ ★

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Year after year, Standard is reinvesting a big share of its income in the never-ending search for petroleum to help meet the growing needs of motorists, industry, home owners, farms and the Armed Forces.

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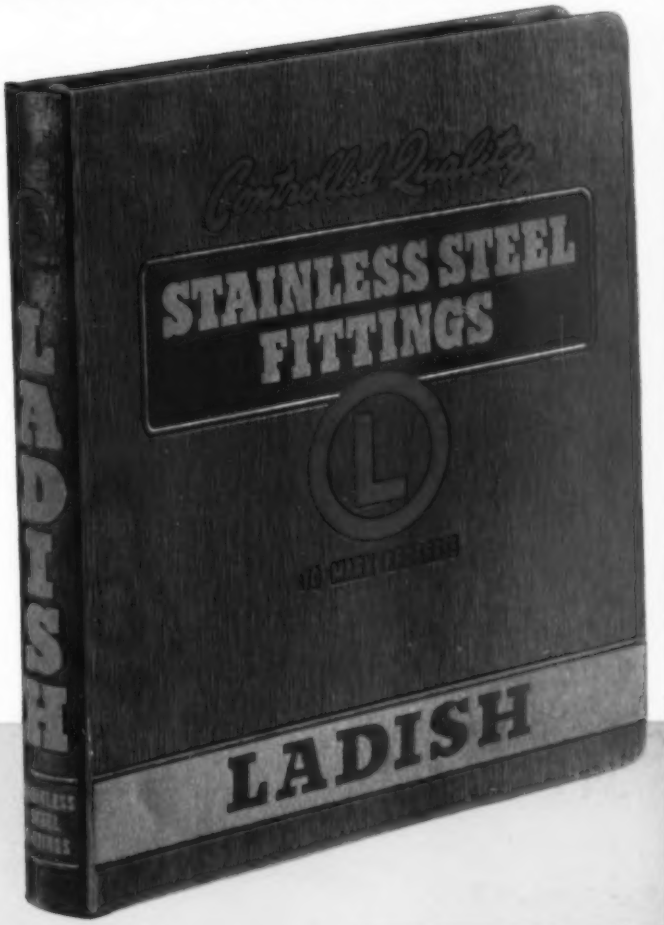

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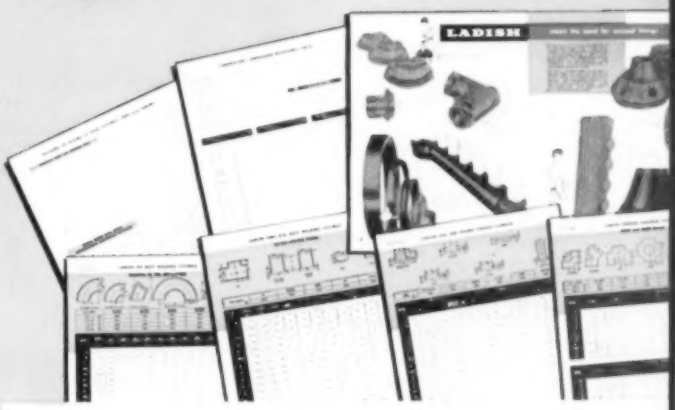

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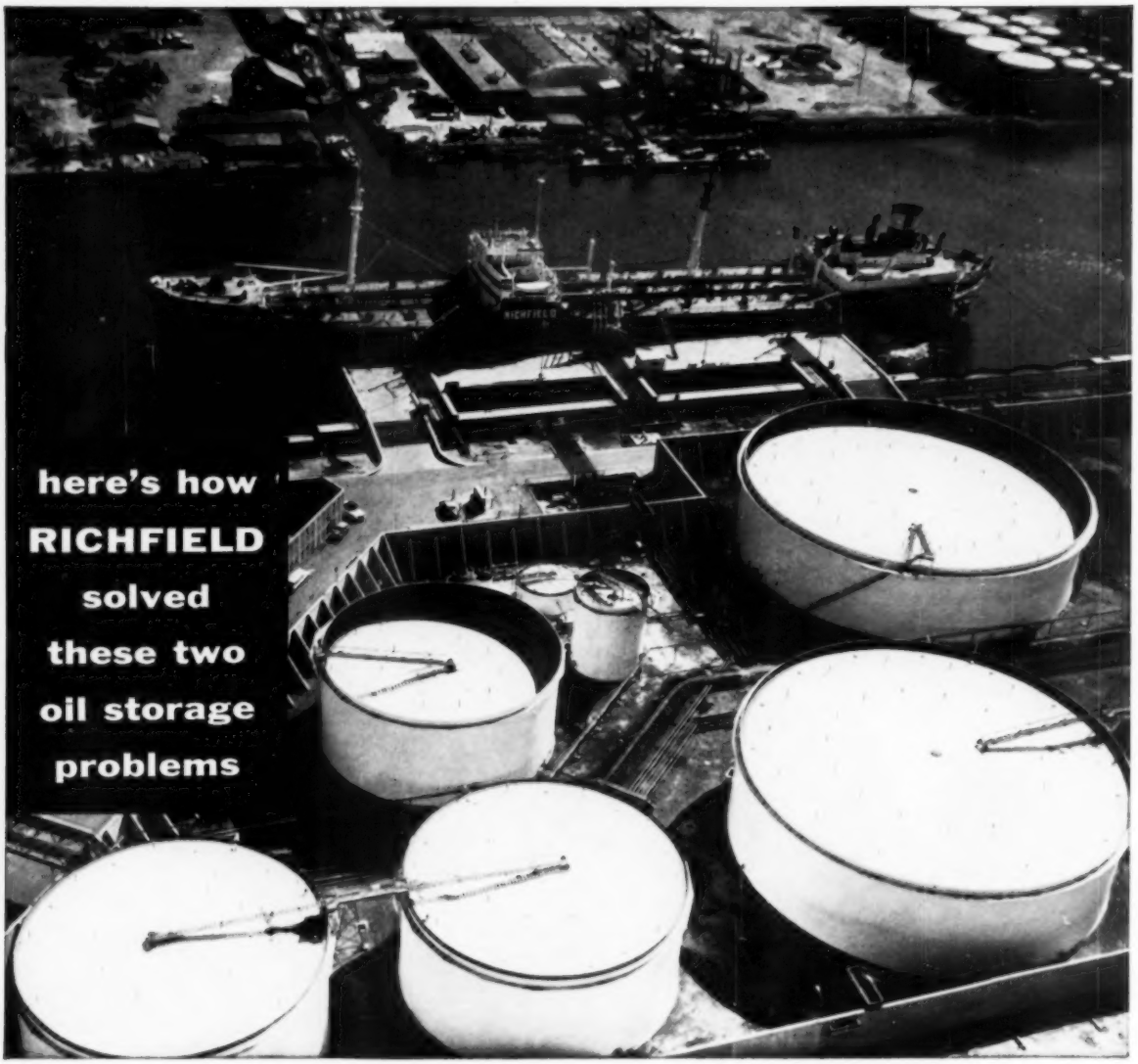

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Herbert F. Koch

EXECUTIVE DEVELOPMENT program of the College of Business Administration of the University of Cincinnati, was first offered in the fall of 1950, with the aim of helping top management to meet the critical need for competent managerial talent.

Its objective is to provide business executives an opportunity to widen their understanding of overall management. A committee was organized by Dean Francis H. Bird, consisting of representatives of business and the university, which would act as a coordinating group and make suggestions in reference to the speakers to be secured and courses to be given.

Classes are held each week for 12 weeks from 2 to 4:30 p.m. on Tuesday, Wednesday, and Thursday. Each class begins with a lecture period which lasts approximately an hour. Then, following a 15-minute recess, there is a question and discussion period in which all members of the group are expected to participate.

The number attending each class is limited to 20. Herbert F. Koch, acting professor of Business Administration, acts as coordinator of the class. Cost of the Advanced Management course is $300 for the 12 weeks which includes payment for the tuition, books, study materials, and certificate.

Faculty for the course consists of both members of the University of Cincinnati faculty, as well as outside lecturers. In addition to the lectures and discussions, a number of sessions are devoted to a discussion of business cases and written reports on actual business situations are submitted.

There is an advisory committee of nine top executives in Cincinnati companies and a coordinating committee composed of 14 business people; the dean and assistant dean of the University's College of Business Administration, and the course coordinator.

Upon satisfactory completion of the course, a certificate of accomplishment is awarded.

Subject matter of the course has been developed under the following main headings:

1. **Function of business** and responsibility of the businessman in the American economy. Lectures include discussions of the Welfare State, inflation, Communism, and the like.
2. **Qualifications** of the business executive in various fields. Lecturers include Walter C. Beckjord, president, Cincinnati Gas and Electric Company; J. G. Pleasants, vice president, Research and Development, Procter & Gamble Company; Fred V. Geier, president, Cincinnati Milling Machine Company; Joseph B. Hall, president, Kroger Company; John J. Rowe, board chairman, Fifth Third Union Trust Company.
3. **Policy-making** and organization procedures.
4. **Government relations.**
5. **Production.** Among speakers are: Dr. A. V. Freigenbaum, General Electric Company, on quality control; Harry Hopkins, vice president, Tool Steel Gear and Pinion Company, on plant layout; Fred Rauch, vice president, Cincinnati Gas and Electric Company, on organization of an industrial relations department.
6. **Marketing.**
7. **Financial management.** One lecturer on this subject is J. J. Hutton, senior partner of W. E. Hutton & Company.
8. **Budgeting** and managerial controls.
9. **Labor relations.** Under this heading there are discussions of collective bargaining in action by Ralph L. Sheets of Emery Industries, Inc., and J. Mack Swigert, partner of Taft, Stettinius & Hollister, law partner of the late Senator Taft, on the Taft-Hartley Act.
10. **Public relations.**

To qualify for admission, an applicant must have demonstrated in his business career, qualities of ability and leadership and must be recommended by the business with which he is associated. There is no formal education prerequisite. ★ ★ ★

Mr. Koch is coordinator of the advanced management course. More information about the class can be obtained by writing him at University of Cincinnati, Cincinnati 21, Ohio.

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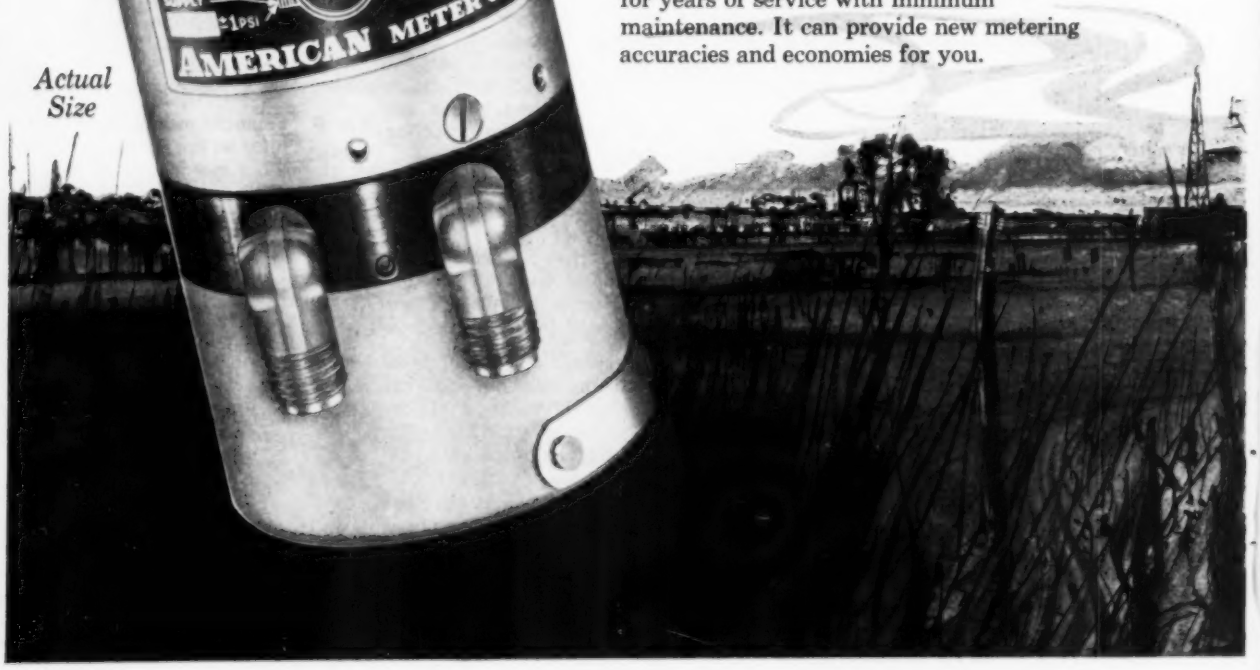

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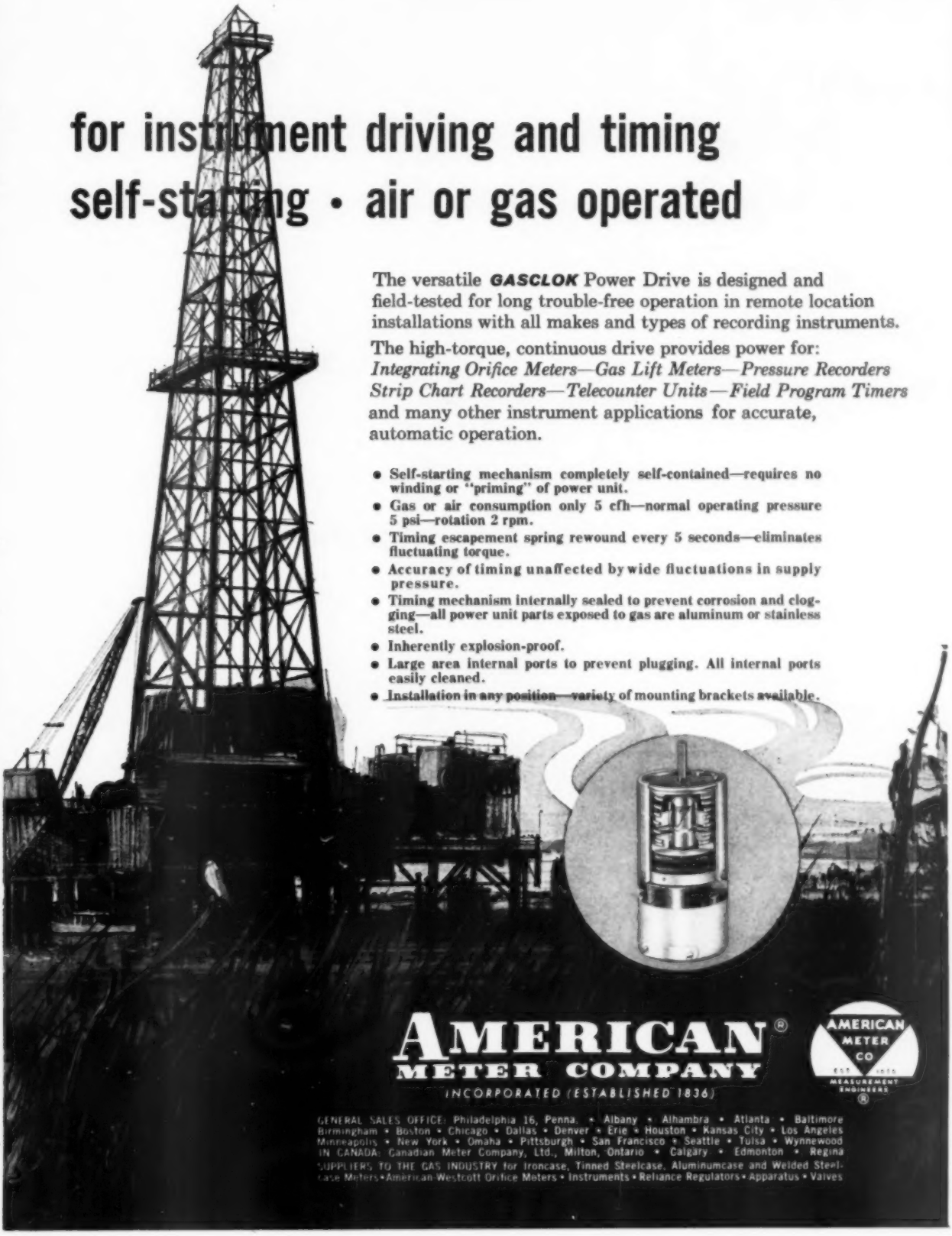


for instrument driving and timing self-starting • air or gas operated

The versatile ***GASCLOK*** Power Drive is designed and field-tested for long trouble-free operation in remote location installations with all makes and types of recording instruments.

The high-torque, continuous drive provides power for: *Integrating Orifice Meters—Gas Lift Meters—Pressure Recorders Strip Chart Recorders—Telecounter Units—Field Program Timers* and many other instrument applications for accurate, automatic operation.

- **Self-starting mechanism completely self-contained—requires no winding or "priming" of power unit.**
- **Gas or air consumption only 5 cfh—normal operating pressure 5 psi—rotation 2 rpm.**
- **Timing escapement spring rewound every 5 seconds—eliminates fluctuating torque.**
- **Accuracy of timing unaffected by wide fluctuations in supply pressure.**
- **Timing mechanism internally sealed to prevent corrosion and clogging—all power unit parts exposed to gas are aluminum or stainless steel.**
- **Inherently explosion-proof.**
- **Large area internal ports to prevent plugging. All internal ports easily cleaned.**
- **Installation in any position—variety of mounting brackets available.**

AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)

AMERICAN METER CO. EST. 1836 MEASUREMENT ENGINEERS®

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta • Baltimore Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston • Kansas City • Los Angeles Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

Management Personals

K. E. Crenshaw

Kirby E. Crenshaw has been elected president of Cities Service Gas Company to succeed **Harry D. Hancock,** who is retiring. Crenshaw has been executive vice president since 1956. He joined the company in 1930. Hancock has been associated with the Cities Service system since 1912. **Lloyd J. Beckman** has been elected secretary and a director of Cities Service Oil Company (Delaware). Beckman succeeds **F. B. Plank** who retires. Beckman, who joined Cities Service in 1929 as assistant chief clerk of the Oklahoma Marketing Division, has been assistant secretary of the company since 1953.

J. P. Moroney, senior vice president of Colorado Oil and Gas Corporation and its subsidiary, Derby Refining Company, has retired. **W. G. Tierney,** president of Derby Refining, will assume Moroney's duties. Tierney will continue as president of Derby and as a vice president and director of Colorado Oil and Gas. **J. W. Meehan,** who has been a Derby vice president, was elected to the Derby board of directors and designated executive vice president and general manager. **L. M. Woodward,** Derby treasurer, was elected a Derby vice president.

The Viscount Monckton of Brenchley (Walter Turner Monckton) was appointed chairman of the Iraq Petroleum Company and Associated Companies succeeding Admiral of the Fleet **Sir John Henry Dacres Cunningham,** retired.

Ira H. Cram was elected chairman of the executive committee of Continental Oil Company's board of directors. Cram, who is a director and senior vice president of Continental, succeeds **E. F. Battson,** retired.

Cram joined Conoco in 1949 as vice president and manager of exploration. He was elected to the company's board of directors in 1952 and became senior vice president the following year. **Serge B. Jurenev,** New York, assistant to the president and chief economist, and **Howard H. Hinson,** Houston, vice president and general manager of Continental Oil Company's foreign department, have been elected to Continental's board of directors. **James J. Cosgrove,** chairman of the board, has resigned.

Eldon A. Siegman has been named senior financial analyst in the Financial and Planning Division, controller's department in the New York offices of American Oil Company. He joined the company in 1946.

Charles A. Buechner, manager of the Ohio Oil Company's Real Estate Development Division, retired September 1 after more than 29 years with the company.

Oscar John Dorwin, formerly vice president and general counsel, has been elected senior vice president of The Texas Company; continues as general counsel. **Marion J. Epley, Jr.,** assistant to the chairman, has been elected a vice president. **Kerryn King,** formerly general manager of the industrial and public relations department, has been elected vice president in charge of that department.

Norman V. Lovett has been promoted to manager of industrial relations for Husky Oil Company and its subsidiary, Husky Hi-Power Inc. Lovett has been assistant manager of the department since joining the organization in November 1955. He replaced **John R. McNulty,** who has been named vice president, industrial relations for Canadian Husky Oil Ltd.

Craig Thompson, veteran newspaperman and free lance writer, has been appointed director, public relations, for the Gulf Oil Corporation. He succeeds **W. R. Huber,** recently retired.

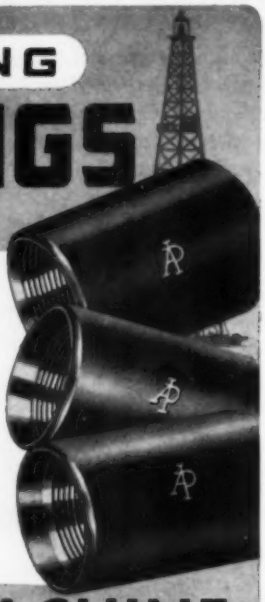
Louis J. Brunel, vice president and general manager of Bishop Oil Company, has been elected a director of the company. He replaces **Prentiss Moore** of Los Angeles, who has resigned. Brunel has been with Bishop since 1926.

Max L. Passante has been appointed to fill the newly created post of director of foreign operations for Lion Oil Company. His headquarters are in Houston, Texas.

C. E. Jester, Houston, Texas, has been appointed industrial relations manager for Continental Oil Company's Rocky Mountain region, with headquarters in Denver. Formerly industrial relations manager for Conoco's southern region, Jester succeeds **Vance A. Knight,** who has been promoted to administrative assistant to the industrial relations manager at headquarters offices in Houston.

WHEELING
COUPLINGS
FOR OIL COUNTRY USE

LINE PIPE COUPLINGS A. P. I.
⅛" to 12" — Seamless and Special Processed — Black or Galvanized
PLAIN TUBING COUPLINGS A. P. I.
1" to 4" — Seamless
EXTERNAL UPSET TUBING COUPLINGS A. P. I.
¼" to 3½" — Seamless
CASING COUPLINGS A. P. I.
4½" to 13⅜" — Long or Short
HYDRAULIC COUPLINGS
⅛" to 4" — Seamless
REAMED AND DRIFTED A. I. S. I.
¾" to 12" — Seamless
DRIVE PIPE COUPLINGS
6" to 12" — Seamless



WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
WEST COAST FACTORY: WOODLAKE, CALIFORNIA

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Baltimore, Md. — Frank Butler, 2301 N. Charles St.
Chicago, Ill. — Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo. — W. G. Cline & Co., 4500 Kalamath
Detroit, Mich. — R. W. Lang, Jr., 505 Park Avenue
Erie, Pa. — R. J. Maggi, Box 711
Falmouth, Mass. — Walter S. Bennett, 5 Belvidere Road
Grand Rapids, Mich. — R. W. Lang, Jr., 138 Burton SE
Houston, Tex. — Henry H. Parts Distributor, Inc., Box 932
Independence, Mo. — Craig A. Fross, 3701 Norwood
Long Island City, N.Y. — Max Rothenberg Co., Inc., 11-05 38th Ave.
Los Angeles, Cal. — James A. Riordan Co., 1400 Santa Fe Ave.
Louisville, Ky. — Sid Schultze Co., 849 S. 6th St.
Narberth, Pa. — Worthington-Grothaus and Associates, 105 Forrest Ave.
Omaha, Nebr. — Wm. Freiden, Central States Engineering & Sales Co., 5101 Blondo St.
Oswego, N.Y. — Northeastern Associates, Neil Chatterton, Sec'y, P.O. Box 284
Portland, Ore. — J. G. Beard Co., 1233 NW 12th Ave.
Richmond, Va. — P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo. — Walter C. Dollinger Co., 4869 Goodfellow Ave.
Salt Lake City, Utah — Lovell Company, 29 E. 2nd St. South
Seattle, Wash. — Ashe & Jones, 819 Thomas St.
Wauwatosa, Wis. — W. G. Nelson, P. O. Box 203

QUALITY-CONTROLLED PIPE COUPLINGS SINCE 1918

IT TAKES A VALVE WITH "GUTS"

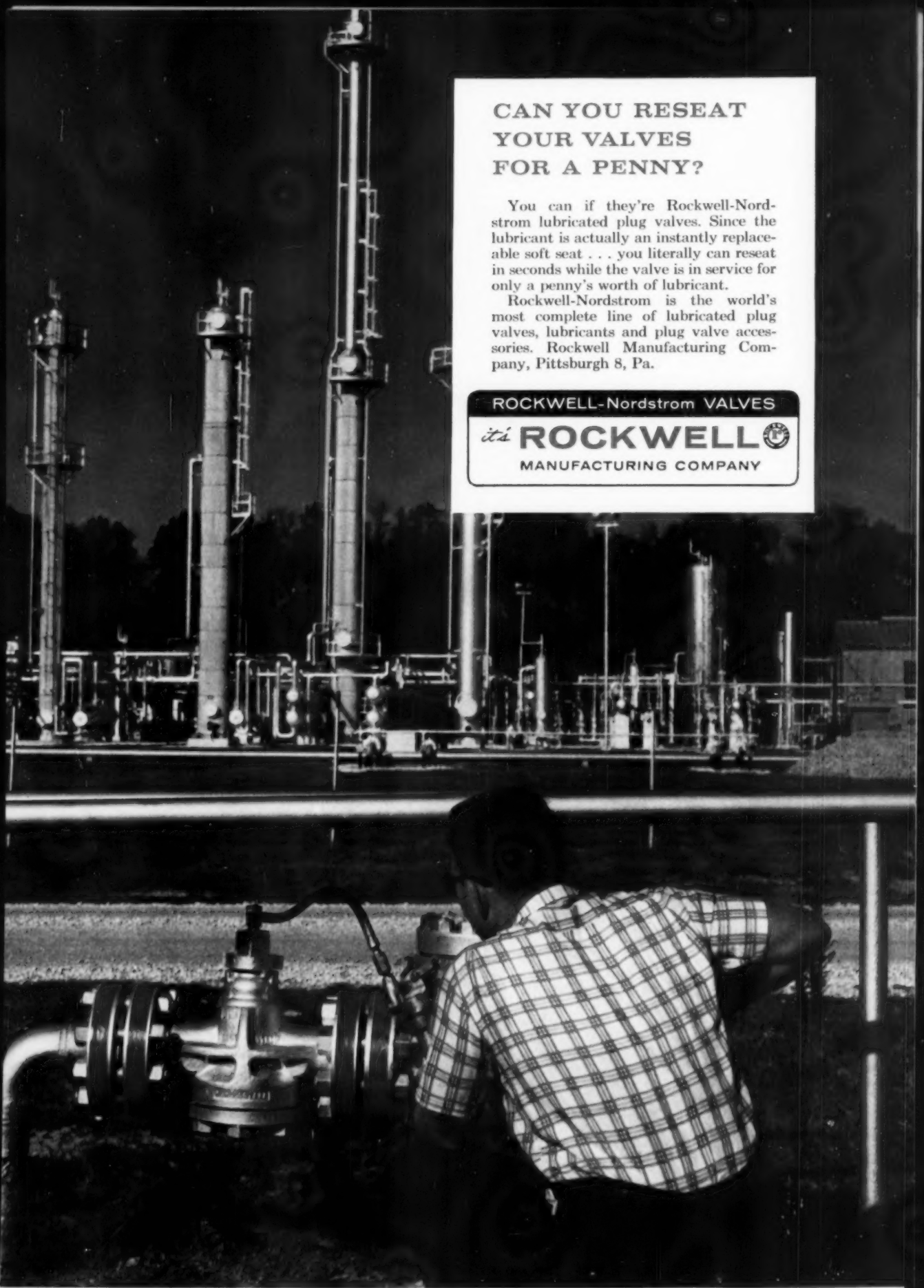
to stay trouble-free and seal tightly on acid and slurry service . . . it takes a Rockwell-Nordstrom lubricated plug valve. Fully protected seats and pressurized lubricant sealing insure positive shut-off, trouble-free operation. Since they cost no more to buy, you pay less for "premium" performance.

Rockwell-Nordstrom is the world's most complete line of lubricated plug valves. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

it's ROCKWELL

MANUFACTURING COMPANY



CAN YOU RESEAT YOUR VALVES FOR A PENNY?

You can if they're Rockwell-Nordstrom lubricated plug valves. Since the lubricant is actually an instantly replaceable soft seat . . . you literally can reseat in seconds while the valve is in service for only a penny's worth of lubricant.

Rockwell-Nordstrom is the world's most complete line of lubricated plug valves, lubricants and plug valve accessories. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

it's ROCKWELL

MANUFACTURING COMPANY

Personals

Hamilton Rogers

Hamilton Rogers, former president of Rowan Oil Company, Fort Worth, has been elected a vice president of Texas Pacific Coal and Oil Company. **A. H. Rowan,** board chairman of the Rowan company, has been elected to the T P board.

Ralph S. Fowler was named special assistant to the Secretary of the Interior **Fred A. Seaton** for oil import matters and as assistant director of the department's Office of Oil and Gas.

As special assistant to the secretary, Fowler will work with **Captain Matthew V. Carson Jr.,** administrator of the Voluntary Oil Import Program. Fowler succeeds **Carroll D. Fentress,** who resigned. Fowler, a consultant to the director of the Office of Defense and Civilian Mobilization, has served previously in the Office of Oil and Gas as foreign petroleum coordinator. He also held the post of director of the Voluntary Agreement Relating to Foreign Petroleum Supply during the Suez Crisis in 1956 and 1957.

Administrative vice president **J. E. Bounds** was appointed coordinator of the financial department, Gulf Oil Corporation. **W. T. Grummer** was named acting comptroller and **W. L. Henry** appointed director of taxes. The financial department is made up of the three previously named men and **H. R. Moorhead,** treasurer.

J. M. B. Howard was granted leave of absence as deputy coordinator of transportation to serve as president of a new affiliate, Esso Tankers, Inc., of Standard Oil Company of New Jersey. The new company was organized to provide technical advice and engineering assistance on ship design, tanker construction and related matters.

Russell D. Richardson was named vice president - finance of Tidewater Oil Company, retaining his present responsibilities as treasurer and controller.

W. B. Cleveland was elected to the board of directors of Creole Petroleum Corporation. He replaces **Dr. W. L. Butte,** who resigned to accept an appointment as professor of law at the University of Texas.

DEATHS

J. E. (Eddie) Prendergast, 31, administrative assistant to the manager of Sun Oil Company's Southwest production division at Dallas, died August 12 following a heart attack.

J. R. (Randolph) Brandon Jr., North Texas sales division manager for the Reed Roller Bit Company, died August 8 of a heart attack.

A. W. Peake, 68, who retired as president of Standard Oil Company (Indiana) in 1955, died August 28 at Dundee, Scotland. He had been president 10 years and a director for 25 of the 34 years he served the company.

Charles D. Wagner, former president of Wagner-Morehouse, Inc., died August 26. He was 71 years old. He organized the Wagner Sales and Service Company in 1936. Later that year he was joined by Harry C. Morehouse at which time Wagner-Morehouse, Inc., was formed. During the next 20 years, he was president of Wagner-Morehouse, Inc., until he retired October 15, 1956.

Manhattan Aladdin

Up East millions of people simply turn a knob to conjure up a genie Aladdin never dreamed of—a genie of warmth and power. In home and industry, Easterners have Texas-Louisiana gas producers to thank for this genie. Transco, like Aladdin's lamp, is happy to carry the genie where the most people are.

TRANSCONTINENTAL GAS PIPE LINE CORPORATION

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

THERE IS NO BETTER TIME to take a close look at the wire rope you use. A look that assures you that for dollars spent you get **services rendered.** The rope you can look at with assurance is **Roebling Royal Blue Wire Rope.** It has been thoroughly tested in our laboratories and proved in the field. It will repay you in hard work for every dollar you spend. **You get your money's worth.** You get **Roebling Royal Blue Wire Rope.**

ROEBLING
ROYAL·1105·BLUE
DESIGN
FOR WIRE ROPE
Its ready adaptability is evident wherever power is transmitted. It conforms to unique design requirements. Use wire rope to transmit power.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

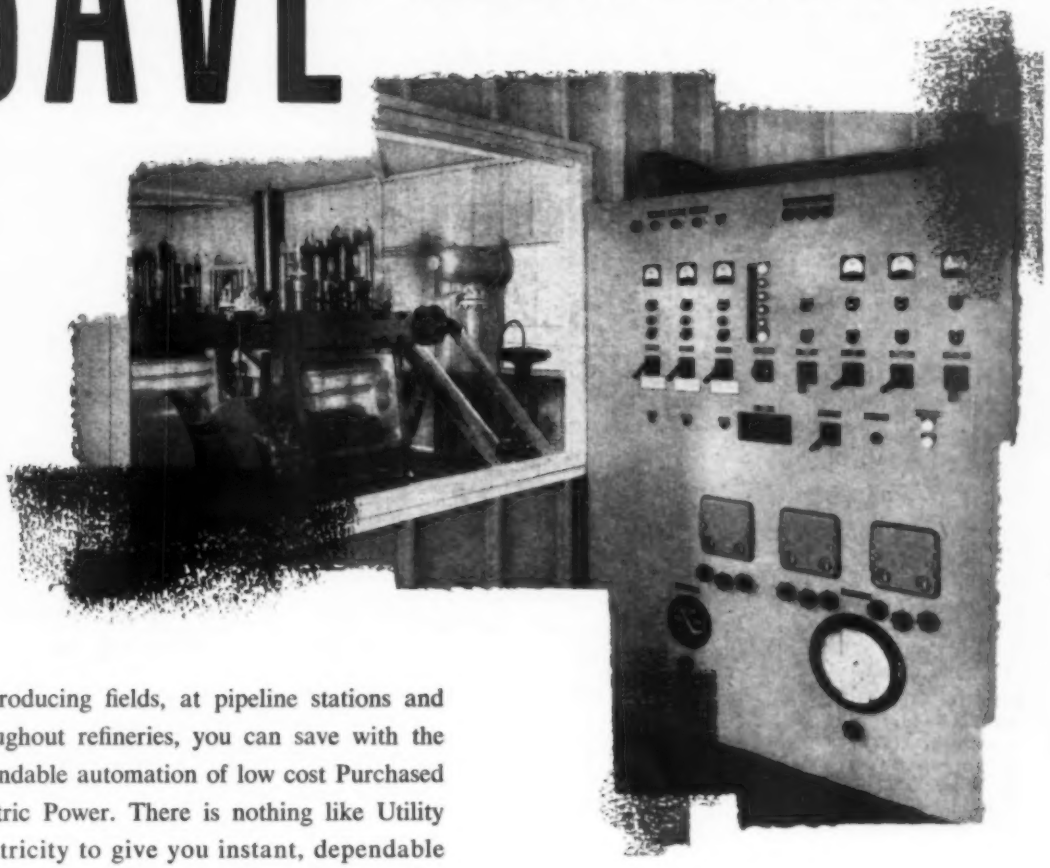
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

SAVE money

SAVE manpower

SAVE maintenance

SAVE with Electric Automation



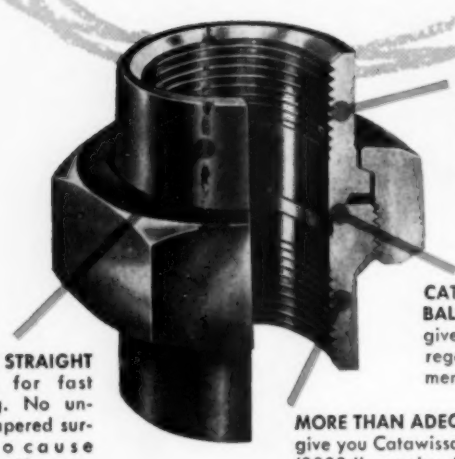
In producing fields, at pipeline stations and throughout refineries, you can save with the dependable automation of low cost Purchased Electric Power. There is nothing like Utility Electricity to give you instant, dependable power when and where you need it . . . and to give you complete automation should you require it for added savings. Let your nearest Utility Electric Power Company show you how you can save more with Purchased Electric Power . . . or write us.

Purchased Electric Power . . .
saves money, manpower, maintenance
and serves you better automatically

Petroleum Electric Power Association

P.O. BOX 35006, DALLAS 35, TEXAS

only
CATAWISSA
gives you all these features for your forged steel pipe union requirements



UNIFORM WALLS for even expansion and contraction under temperature changes. THEY FOLLOW THE PIPE!

CATAWISSA BALL-TO-ANGLE SEATS give you a "Perfect Seal" regardless of pipe alignment!

ROUND, STRAIGHT BARRELS for fast wrenching. No uneven or tapered surfaces to cause wrench slips or wrench locking!

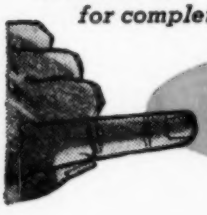
MORE THAN ADEQUATE wall thicknesses give you Catawissa's 3-to-1 Safety Factor (3000-lb. service, 9000-lb. test; 6000-lb. service, 18000-lb. test)!

Catawissa Perfect Seal Pipe Unions are made by Union Specialists from 80,000-lb. tensile strength steel (ASTM Spec. A-105-55T, Grade II). Steel forgings from our own forging mill are closely checked for imperfections . . . and finishing on modern, automatic machines with close inspection during and after production give you pipe unions second to none!

Get your free copy of Catalog 56 showing the complete Catawissa line . . . write direct or stop at your favorite supply store.

CATAWISSA VALVE & FITTINGS COMPANY • CATAWISSA, PENNA.

for complete, guaranteed pipe union satisfaction



. . . always specify
CATAWISSA

. . . at your favorite supply store

Laugh with Barney

Toolpusher: "Give me an example of wasted energy."
Roughneck: "Telling a hair-raising story to a bald headed man."

Scientists say that mosquitoes weep. Is that true?
It's possible. I've seen a moth ball.

After looking around the campus a little, statistics show that blondes make the best students.

"Nurse," said the amorous patient, "I'm in love with you. I don't want to get well."
"Cheer up, you won't," she assured him, "the doctor's in love with me, too, and he saw you kiss me this morning."

Little Boy (looking at mother's new evening wrap): "How that poor beast must have suffered so you could have such a fur coat."
Mother: "Hush, Johnny. You shouldn't talk like that about your father."

Two Scotchmen met on the street. The one recognized that the other was drunk, so he handed him a dollar bill and said, "Well, Sandy, here's that two dollars I owe you."

Stage Manager: "I hear you and the leading lady are on the outs."
Electrician: "Yeah. It was one of those quick scenes with the stage all dark. She asked for her tights and I thought she said lights."

Among the things which Emily Post forgot to mention — the tactful way of asking a gangster's daughter to go out for a ride.

"Young lady, do you mean to tell me you've been carrying that money around in your stocking?"
"Why Daddy, you told me to put it where it would draw interest."

Sign on a college bulletin board: "Good courting car for sale. Owner needs money to buy baby buggy."

The sweet young thing cashed the check given to her by her wealthy playboy friend. To her surprise, it bounced. It was marked "Insufficient Fun."

The traffic was heavy. A man and a woman driver collided at a busy intersection. A nearby policeman walked over, listened to the dispute, and offered this advice to the man.
"I'd settle if I were you, sir. After all, it's your word against literally thousands of hers."

We heard about a musician who worked all week on an arrangement — and then his wife didn't go out of town after all.

The difference between a wife and a secretary is that a secretary takes dictation and a wife gives it.

Small boy: "Daddy, what is untold wealth?"
Father: "It's the money a man wins in a poker game and doesn't tell his wife about."

A New Way to Tell the Story* of GASOLINE PROGRESS!

*** to your friends, your neighbors, your customers**

CUSTOMER: What's the best way to measure gasoline performance?

DEALER: The best and newest way to measure gasoline performance is in "ton-miles" per gallon.

CUSTOMER: What are "ton-miles" per gallon?

DEALER: That's the distance one gallon of gasoline will move one ton of automobile. It takes into account the varying weights of today's cars.

CUSTOMER: That sounds reasonable, but what does it prove?

DEALER: That with today's gasoline, you drive a real bargain! Measured by the "ton-mile," today's gasoline does 70% more work than gasoline did in 1930.

CUSTOMER: 70%? That's a terrific improvement in gasoline performance.

DEALER: Right! In 1930, the average car on the road gave 25 "ton-miles" per gallon. Today, the average is 43 "ton-miles."

CUSTOMER: But how about the cost of gasoline per gallon?

DEALER: You gain there, too! In 1930, you spent ⅔ of a cent for gasoline for each "ton-mile." Today, you spend only a little over ½ a cent for each "ton-mile" you drive.

DEALER: *You're getting 70% more work out of your gasoline, and you're saving 18% while you do it!*

CUSTOMER: Fill 'er up!

The "TON-MILE" Story is the story of gasoline progress. Tell this story every chance you get. It'll be good for *your* business!

American Petroleum Institute, Dept. G
50 W. 50th Street, New York 20, N. Y.

I would like to obtain more information about today's gasoline quality, prices and taxes. Please send me your FREE booklets.

NAME _____

ADDRESS _____

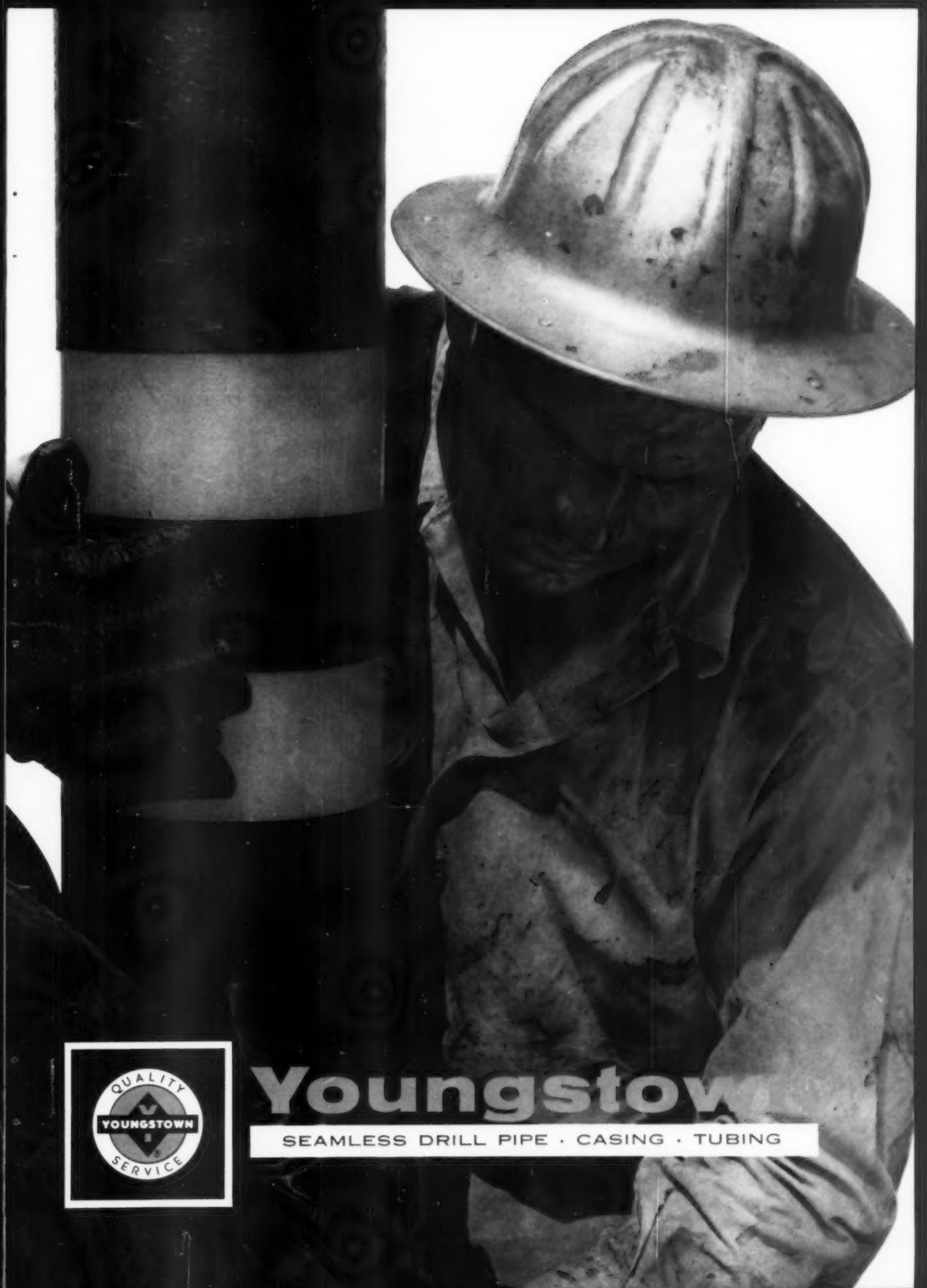
CITY _____ **ZONE** ____ **STATE** _____

REMEMBER OIL PROGRESS WEEK—OCTOBER 12th to 18th

WHEREVER YOU FIND PIPE WITH ORANGE BANDS YOU'LL FIND A SMART PIPE BUYER

Youngstown's Oil Field Service Corps—nine qualified engineers—stand ready around-the-clock to consult on all your drilling problems. These professional men have offices in the oil fields and will gladly lend you their knowledge and long experience—either prior to drilling or during actual operations. They can tell you, too, about the pipe with the orange bands, the finest seamless pipe made anywhere. Call your nearest Youngstown District Office, today.

THE YOUNGSTOWN SHEET AND TUBE COMPANY
Youngstown 1, Ohio


QUALITY
YOUNGSTOWN
SERVICE
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SEAMLESS DRILL PIPE · CASING · TUBING

USSR COMPETES IN WORLD OIL MARKET

Foreign trade magazine boasts that the Soviet is taking sales away from Western oil companies . . . Released figures to 1957 show sharp rise in Communist exports

Ernestine Adams

THE Middle East and Venezuela, largest oil exporters, find a new competitor rising with dangerous rapidity. An issue of Vneshnayaya Torgovlya, official organ of the USSR Ministry of Foreign Trade, boasts that "during recent years the Soviet Union has replaced the American and Anglo-Dutch monopolies in selling liquid fuel to many countries in Africa, Asia, and Latin America."

The 1957 figures, although not available, have been hinted at and estimates are that the increase will be at least 25 percent above exports for 1956.

Deals made with the Soviet for oil and oil products are usually for exchange of products instead of cash. The Communist government, of course, uses this trade as the economic tool of political policy. Political officials decide how much to export, which may ignore domestic needs; at what price, which may be at a loss or a profit, and to whom. If the sale or exchange takes a market from Free World oil companies, so much the better.

Russian oil exports to both Communist and non-Communist countries passed the 10 million metric ton mark (about 205,000 bbl a day) for the first time in 1956.

Latest official Soviet figures for oil and oil products exports are in Table 1.

Highest level of Russian oil and oil products exports before World War II was 5.2 million metric tons (10,500 bbl a day) in 1931.

The USSR Ministry of Foreign Trade says that with the exception of Rumania, all the Communist nations in Europe are substantial purchasers of Russian oil or oil products. During recent years, Communist China has been the largest buyer of Russian oil products. Soviet oil exports to Red China increased 10-fold between 1950-1957. In 1957 USSR delivered 14 million bbl of oil and oil products to its neighbor.

In 1956 — last year for which official statistics are available — about 35 percent of Soviet oil and oil products to non-Communist countries went to Africa, Asia, and Latin America, about 20 percent to Finland, and about 35 percent to Western Europe.

Russian oil and oil products imports during the postwar period are in Table 2.

Imported oil products came mainly from Rumania, Hungary, and Albania; synthetics, East Germany. Most of Russia's imported crude was provided by Albania.

In our annual world-wide survey of petroleum operations* we were struck by Soviet competition outside its borders for oil resources and by the number of Communist petroleum engineers working in other countries, such as Egypt, India, Ceylon, and Syria.

The Standard Oiler† goes into another phase of USSR competition — this one on the technological side. Several months ago *Life* quoted a Russian scientist as saying the Soviet petroleum industry had developed a drilling rig capable of drilling to 50,000 ft.

In a round table in Houston, Texas, later, U. S. drilling experts agreed our technology and equipment could drill 50,000 ft.‡

The turbodrill is an exhibit of the Soviet's attention to technological development in the petroleum field.

There is little question the USSR production is increasing rapidly — about 17 percent last year. Demand is what the government decides. Remember there are only five service stations in the capital city of Moscow.

Speaking of the Soviet Union's growing oil export capacity, Allen W. Dulles, U. S. Central Intelligence Agency director, warned: "By withholding supplies, by capriciously raising prices, or by dumping commodities, the Soviets in effect will have a seat at the council table of the great industrial nations of Europe."

The political power that could be wielded by control of cheap oil energy in the Middle East under such a policy could keep the world in perpetual hot water. It is perhaps one good reason for the drastic move of sending troops into Lebanon and Jordan to keep stability in the area.

In this age, a dictator who controls a nation's energy sources can decide the economic condition of that nation and influence the political situation.

★ ★ ★

*The Petroleum Engineer, July 1958, Page A-17.

†July, 1958, issue of magazine published by Standard Oil of California.

‡*The Petroleum Engineer*, March 1958, Page B-44.

TABLE 1. USSR Exports of Oil and Oil Products.

	1938	1946	1950	1955	1956
1000 metric tons/year	1,400	500	1,100	8,600	10,000
Bbl/day	28,000	10,000	22,000	162,000	205,000
Including:					
Communist countries (1000 T)		400	900	4,200	5,300
Bbl/day		8,000	18,000	85,000	107,500
Capitalist countries (1000 T)		100	200	3,800	4,800
Bbl/day		2,000	4,000	77,000	97,000

TABLE 2. USSR Oil Imports.

	1946	1950	1955	1956
Metric tons (1000)	900	2,600	4,400	5,300
Bbl/day	18,000	53,000	89,000	107,500

• News • People — The Trade PARADE

APPOINTMENT OF the Frost Engineering Service Company, San Francisco, as exclusive Southern California distributor for F. H. Maloney Company pipeline specialty products has been announced. Vern Frost, a specialist in the oil and gas industries since 1946, is president of the company. Associated with Frost are John Merrill, general manager of Frost Engineering; and Jack Crawley, office engineer-manager of the firm.

INTERNATIONAL MANAGEMENT organization known as Kendavis Industries, Inc., International, has been formed comprising 19 affiliate companies. Officers announced by Ken W. Davis, president, included: Vice president and comptroller, Ken Davis, Jr., chairman of the board, Loffland Brothers and Unit Rig & Equipment; general vice president Thomas N. Shults, president of Mid-Continent Cummins Export Corporation and a Mid-Continent vice president; vice president-communications, Victor LeMay, Mid-Continent public relations and advertising director; vice president-manufacturing, John W. Tullis, Stratoflex vice president and general manager; vice president-drilling, R. J. Bromell, former Great Western Drilling chief engineer.

Ken W. Davis

T. N. Shults

Ken Davis, Jr.

Following are with Mid-Continent: Vice president - merchandising, P. Z. Hilliard; vice president - traffic, Dan C. Rogers; vice president - treasurer and assistant secretary Walter E. Strittmatter; vice president - real estate Jack P. Jones; vice president - legal counsel Warren Scarborough, Mid-Continent director; and secretary and assistant treasurer B. L. Coontz. The advisory committee established for Kendavis Industries, Inc., International includes: Mid-Continent president D. H. Thornbury, Mid-Continent secretary-treasurer M. C. Cornish, Great Western president R. C. Tucker, Loffland Brothers president R. W. Wire, president Dorris Ballew of Dorris Ballew, Inc., Unit Rig president J. L. Vint, Cummins Sales & Service president J. T. Calnon, Stratoflex president C. A. Thomas, Cummins Sales & Service de Venezuela vice president and general manager L. J. Troutz, Loffland Brothers de Venezuela, C.A., vice president and general manager W. F. Ogden, and CP-Harrisburg, Inc., president T. P. Tarwater.

J. T. Calnon, formerly vice president - sales, is new president of Cummins Sales and Service, Inc.

REFINERY SERVICE has been extended in the Rocky Mountain and Louisiana Gulf Coast areas by Tretolite Company division of Petrolite Corporation. Philip P. Corneli, formerly chemical engineer for Shell Oil Company at Wood River, Illinois, will be at Baton Rouge, Louisiana. Dan Pietuch, refinery service engineer for Tretolite in Chicago has been transferred to Billings, Montana, where he will service the Rocky Mountain and western Canadian refineries.

NEW AGENT for Cameron Iron Works, Inc., is James H. Withers and Company, who will handle Cameron Lift-Plug valves on the West Coast. Withers was formerly a sales-engineer with Cameron for five years. His offices are in Long Beach, California.

CENTURY GEOPHYSICAL Corporation, Tulsa, Oklahoma, announced that Century has joined with Schlumberger Well Surveying Corporation to form a geophysical velocity logging service to be known as the Seismic Reference Service (SRS). Century has established a data center in its Tulsa office headquarters in order to process and evaluate results obtained by its field SRS crews.

SEVEN NEW APPOINTMENTS and reassignments in its oilfield sales and service divisions have been made by Mission Manufacturing Company. In the service field, Tony Volotko was named service engineer to operate out of the Houston office. Originally, he was a field sales representative. Moving to New Iberia, Louisiana, from Houma as field sales representative is Harold Herrin who was formerly service engineer in Houma. Joe Scalise was reassigned from New Iberia to Houston as a field salesman. Appointed city sales representative for the Dallas-Fort Worth area with headquarters in Dallas is R. E. (Jack) Hardy. A. E. Robinson was transferred from Abilene to New Orleans, and R. M. Wood shifted from Illinois to Oklahoma City. Replacing Wood in Illinois as field sales representative is Joe Young from Oklahoma City.

SOUTHERN ENGINE and Pump has been appointed distributor for Roi Line Engines, manufactured by Waukesha Motor. Waukesha recently purchased Le Roi Engines and renamed it the Roi Line.

TEXAS GULF DISTRICT headquarters for Bethlehem Supply Company have been moved from Houston to Beaumont, Texas. Relocation was necessary to obtain a more central point. O. H. Crowe, Texas Gulf district manager, will have his headquarters in Beaumont.

W. J. (Bill) Vark is new district manager of the Louisiana Gulf district, with headquarters at New Orleans. Vark, formerly district machinery sales representative, replaces J. B. (Bob) Ellzey, deceased.

REXALL DRUG COMPANY has purchased Chemtrol Company of Lynwood, California, it was announced by Justin W. Dart, Rexall president. Martin Usab, designer of the valve and a principal of Chemtrol, will head the research and product development department of the combined companies, Dart announced. All employees will be retained.

Baker Oil Tools, Inc. E. H. Clark, Jr., has been named vice president and assistant general manager, to carry out administrative functions at Los Angeles. He formerly was head of the research department. W. S. Althouse, Jr., recently elected a member of the board of directors, was named manager of engineering and research. Althouse formerly was chief engineer. G. D. Hall, assistant secretary-treasurer, and formerly assistant manager of the Central Division, was appointed administrative director of the Baker Houston plant. Paul E. Hilton, newly elected vice president and a member of the board of directors, will continue as manager of sales and service, Central Division.

Christensen Diamond Products Company. Tom Manuel, formerly Salt Lake City district manager and Hugh Wallace of the Oklahoma City district, are being transferred to Christensen's affiliate company Christensen Diamond Products Company (France). Manuel will be in Celle, Germany, where he will work through a subsidiary company, Christensen Diamond Products GmbH. Wallace will be stationed in Rome, Italy.

A. E. Carter

H. F. Nostrand

Worthington Corporation. A. E. Carter has been elected vice president of manufacturing. He will succeed Leslie C. Ricketts, who will devote full time as group vice president of five Worthington operating divisions. Carter joins Worthington from the Ford Motor Company.

W. C. Norris, Manufacturer, division of Dover Corporation of Tulsa. H. F. Nostrand has been appointed advertising manager. He has been with Norris since 1946 and will serve under G. W. Davidson, Jr., vice president - sales.

W. R. Wheeler, Jr.

J. W. Robbins

American Iron and Machine Works Company, Inc. W. R. Wheeler, Jr. has been elected vice president in charge of sales. He was formerly sales manager in Oklahoma City.

Fern Wagner and Joe Thompson have been appointed assistant sales managers.

Parkersburg-Aetna Corporation. J. W. Robbins has been named vice president and general sales manager of Parkersburg Rig and Reel Company, division of Parkersburg-Aetna. He succeeds A. G. Evans-Lombe, who resigned as general sales manager and will continue as vice president. Robbins has been with the company 18 years.

MAXIMUM WORKING PRESSURE
10,000 PSI
for water, oil or gas

- Body and stem guide extra heavy bar stock fused into one piece.
- Valve stem 416 stainless steel.
- Packing special one-piece "Marpak" moulded ring.
- Bodies marked in accordance with MSS regulations.

Marsh Needle Valves for Special Applications

For high pressure air service, Series R1900, hardened stem, Marpak packing system.
For oxygen and helium service, Series R1924, chemically pure, and with Marpak-Teflon packing system.
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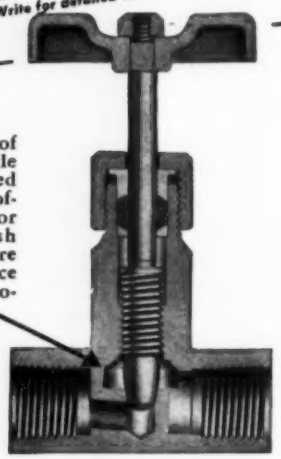
ONE PIECE

The stem guides of conventional needle valves are screwed into bodies—this often causes leakage or blow-outs. Marsh Needle Valves are fused into one-piece by exclusive "Conoweld" process.



The Ultimate in Needle Valves

Here is one of the crowning achievements of Marsh research, design, and manufacturing skill. It is the first needle throttling and shutoff valve to combine *all* of the qualities called for today in this highly critical and ever broadening field.

It is a valve that has strength and safety to spare . . . rated for pressures up to 10,000 psi—equally efficient in the lower ranges. A product of Marsh instrument-making and valve manufacturing experience, it combines instrument-like precision with the ruggedness that distinguishes all Marsh valve specialties.

The illustrations tell the story of new thinking; new standards. Body and stem-guide are machined from extra-heavy carbon steel bar stock. Still greater strength and rigidity are achieved by fusing the stem-guide into the body. The complete fusion of guide and body is accomplished by the exclusive Marsh "Conoweld" process.

There are two big advantages to this one-piece construction: (1) It eliminates the danger of unscrewing the valve from the body when opening—a frequent cause of leakage, even dangerous blow-outs (2) It permits perfect line-up of threads and seat. As a result, Marsh valves are easier to operate even at high pressures.

The precision-machined stem is 416 stainless steel. Stem threads are fine pitch for extra strength and fine, controlled regulation. Notable advancements are special "Marpak" one-piece, non-binding longer-lasting packing; deep thread chambers, keeping inlet and outlet piping away from ports and contributing excellent flow characteristics. Entire packing nut and packing gland are electro-zinc plated, preventing corrosion and giving the valve a handsome, plated exterior. The rugged malleable handle is finished in heavy baked enamel.

The new needle valve line includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1". Also globe and angle valves with male inlet and female outlet in sizes ¼" and ½". *Complete stock carried at our Skokie, Illinois factory and also at our branch plant in Houston, Texas.*

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MARSH

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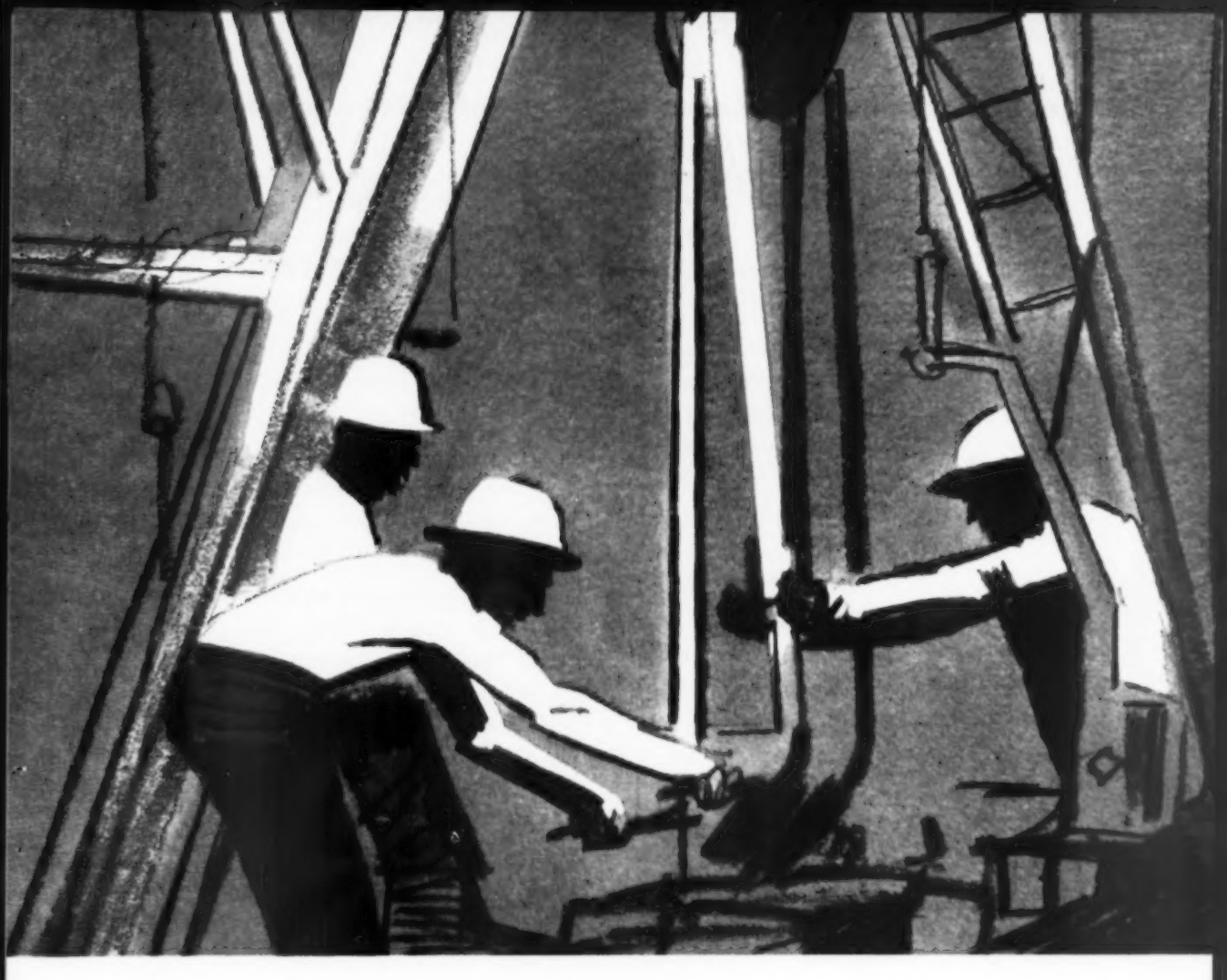

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Layne wells circle the globe. Every condition and every problem possible has been met and solved. This know-how and over three quarters of a century of experience result in efficient, economical wells—the basis of many industrial water systems. Layne drilled wells provide a reliable water source—the criterion for industrial water supply.

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AUTOMATIC LEASE CONTROL

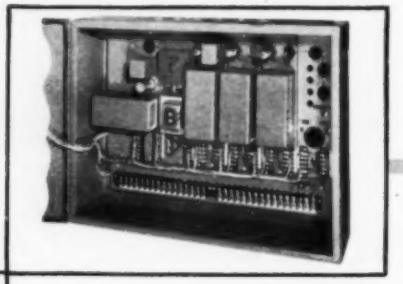
Individually designed and engineered!

The line illustration on the right represents a typical automatic well test system. The "Cyclotest" Automatic Well Test Control Panel, pictured below this illustration, is connected to three-way solenoid actuated diverting valves installed in each flow line production manifold. A valve, when actuated, diverts the flow of oil through the well test equipment, comprised of a test separator or heater-treater and meters for oil, water and gas. Each meter actuates a momentary contact for each unit of production. This test information, in the form of electrical pulses, can be recorded by various pens in an associated strip chart operation recorder or in digital form by the CSC "Cycloprint" DATA Printer, shown below the illustration on the right. Also recorded are well identification numbers and duration of tests.

If Fisher Type 1620 three-way, 3 position valves are used in the production manifold, the "Cyclotest" panel can be provided with clocks for well flow control for automatic stop-cocking of wells.

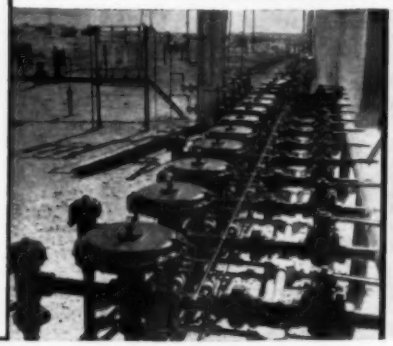
High Level Safety Float Switches, Fisher Type 2800-252V, are installed in both test and production separators. High level in Test Separator carries oil to be diverted back through Production Separator; high level in Production Separator can be used to actuate a lease shut-in circuit.

Internal Construction of CSC "Cyclotest". Individual relays are hermetically sealed and plug-in. This minimizes the need for maintenance and at the same time makes servicing of this unit quite simple. The sub-base on which the plug-in components are mounted is hinged and swings out for easy access to all internal wiring.

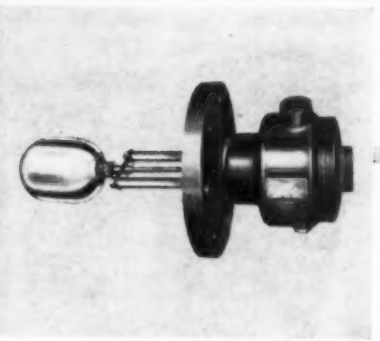


FOR COMPLETE DETAILS WRITE FOR BULLETIN 901

The Type 1620, pictured above, is a three-way, three-position valve. With no pressure on the diaphragm both ports are closed, so that this valve can be used for production control in addition to automatic well testing. The body is rated at 1500 lbs. W.O.G. working pressure and has 2" screwed connections.



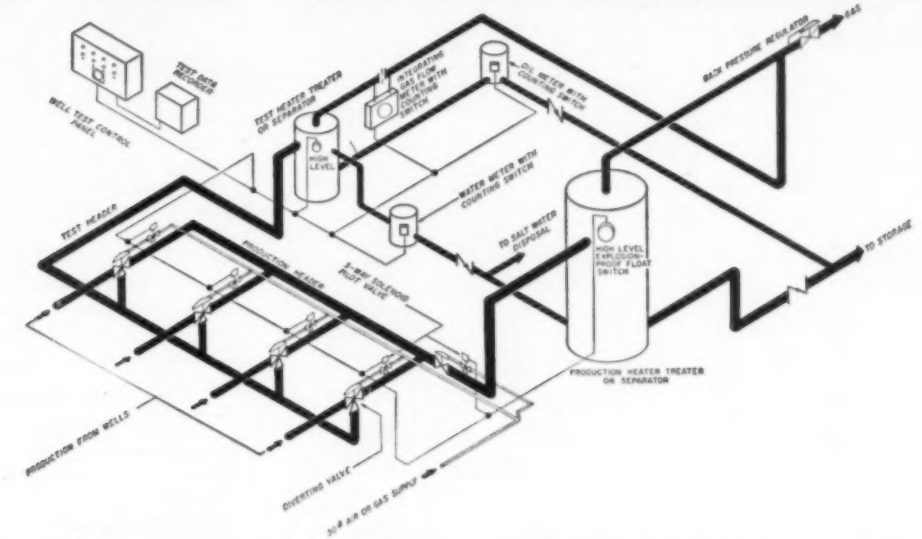
Pictured above are Diverting Valves for Well Test Manifold. Fisher offers two valve types for this service. For straight three-way service at low pressures the Type 1663A is recommended. This valve is spring loaded, diverting to the (test) position only when air is applied under the diaphragm.



Float Level Control. The Fisher Type 2800-252V, an on-off type float switch, uses a flexure tube assembly for transmitting float motion to a Micro switch in an explosion-proof housing. Also available with Type 2805 pneumatic snap-acting pilot—interchangeable on same housing.

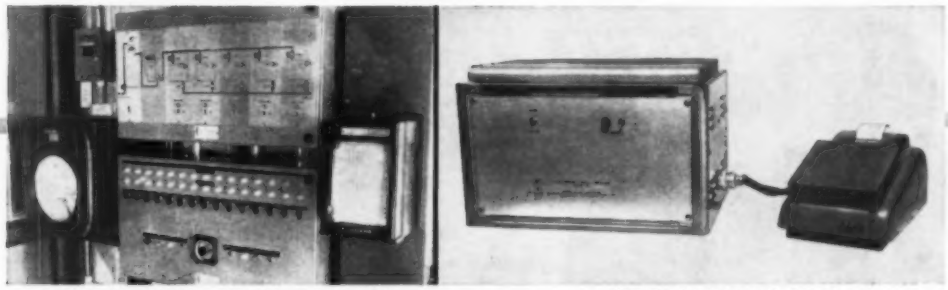
CITY STATE

AND WELL TESTING EQUIPMENT



The left illustration below shows the controllers and recorders for a combination automatic tank switching and automatic well testing installation. The graphic panel is a CSC "Cyclotest" Automatic Well Test Controller for programming the testing of 15 wells. The recorder on the left is the integrating gas flow meter. On the right is a multi-pen operation recorder providing a permanent record of well test data.

The pilot lights on the "Cyclotest" indicate which wells are flowing straight to the Production Separator and which well is on test. The row of switches directly under the lights provide for by-passing wells from test sequence, for shutting wells in or for putting them on test independent of the controller. In the lower center is a 1-30 hr. timer which determines the duration of the test.



"Cyclotest" Automatic Well Test Controllers *"Cycloprint" Data Printer*

Pictured on the right in the above illustration is a "Cycloprint" Automatic Data Printer which is a multi-channel unit designed to receive pulse information from as many as 21 different sources and store this information until called for. A typical application is the recording of well test information such as barrels of oil and water, MCF of gas, test time, lease identification, date and time. The information is printed in digital form on adding machine tape.

CSC

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FAST ASSEMBLY
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Stops rusting, acid-etch and corrosion.
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EASY DISASSEMBLY ANYTIME
Better than new threads.

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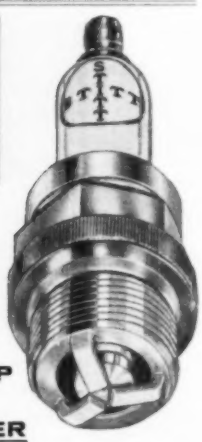

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Trade Parade

R. W. Rademacher

L. P. Harman

NEW EASTERN district office in New York City to serve that market better has been announced by J. Pat Beaird, president of The J. B. Beaird Company, Inc. R. W. Rademacher, formerly manager of plant storage, has been promoted to manager of Beaird's Eastern division.

Well Completions, Inc. Lyndon P. Harman is new sales manager of Well Completions, Inc. Harman will also aid the firm's staff in engineering air or gas drilling programs for contractors and operators.

Wilson Supply Company. James Grady Ferguson has been transferred from the Houston, Texas, office to the sales office in Tulsa, Oklahoma, where he will assist P. S. (Phil) Stover, manager. Ferguson has been with the company 12 years. He is being replaced by Herbert Reimers.

Consolidated Electrodynamics. Appointment of Everett J. Long as director of the transducer division was announced. Long, who succeeds Patrick in the divisional director's post, was formerly assistant director for operations of the division. Joining CEC in 1952, he was manager of the special products division before becoming production manager of the transducer division in 1956.

Jones & Laughlin Supply Division. Appointments of two district sales managers have been announced. V. A. Hamilton, salesman at Pleasanton, Texas, will be in the Panhandle District with headquarters at Amarillo, Texas. O. M. Lorenz, assistant district sales manager of the Illinois-Kentucky district, will have headquarters at Olney, Illinois.

General Motors. Arthur M. Hazell, Jr., was appointed manager of petroleum equipment sales for Electro-Motive Division, builder of diesel-electric power equipment for oil well drilling. Hazell, who has been sales representative at Houston for Electro-Motive, will be assisted by two factory service engineers — Thurlow Fernandez at Houston and Ed Chernoff at New Orleans.

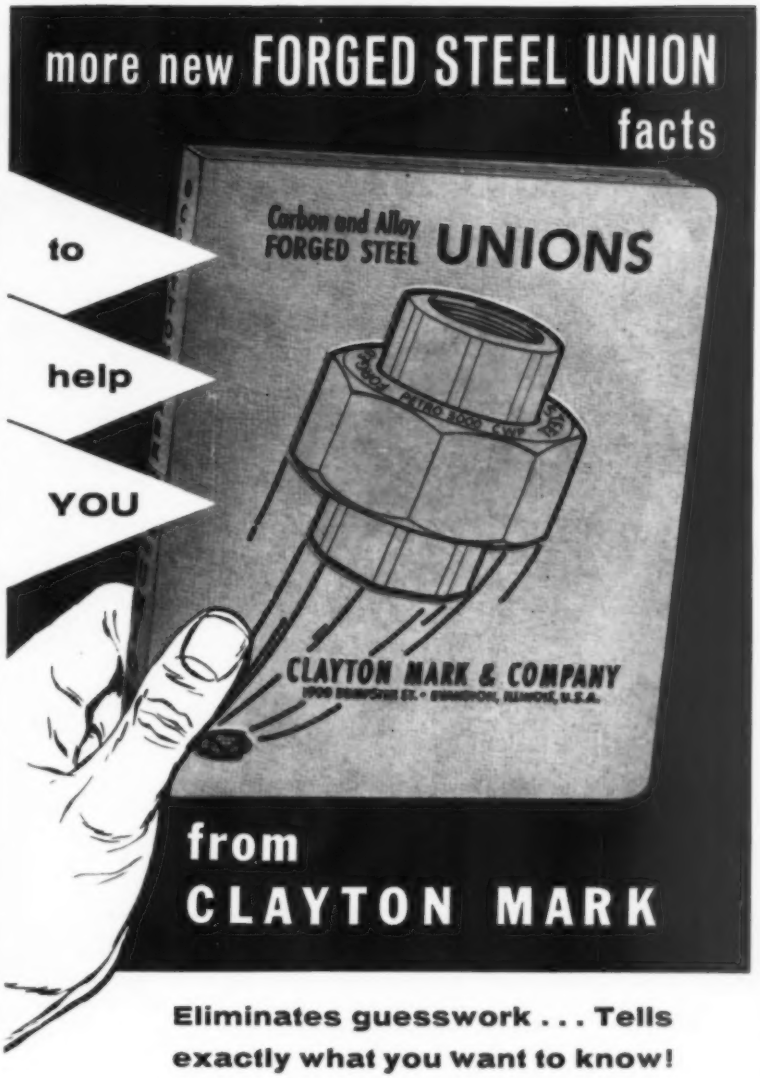
Crutcher-Rolfs-Cummings. President A. S. Crutcher and first vice president J. D. Cummings, co-owners of the firm, placed the active management of the company in the hands of three new vice presidents and a secretary-treasurer.

Kenneth Defenbaugh, previously a partner in an Oklahoma City company which supplied certain equipment to C-R-C, has assumed office as vice president and general manager.

C. E. Hatcher who has been in charge of C-R-C's Internal Pipe coating division was made a vice president.

Jack Scott, previously sales and service manager, is the new vice president in charge of sales and service.

W. C. Cherry, with C-R-C since 1946, was chief accountant and comptroller prior to his being promoted to the secretary-treasurer post.



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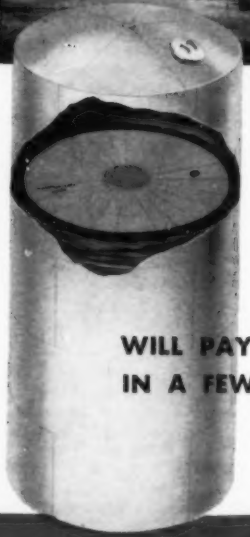

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...and PAYS
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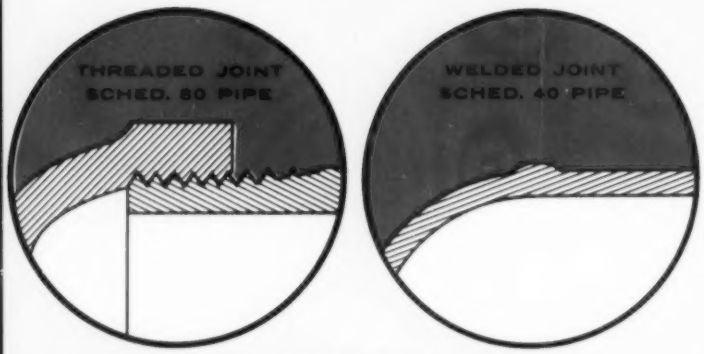
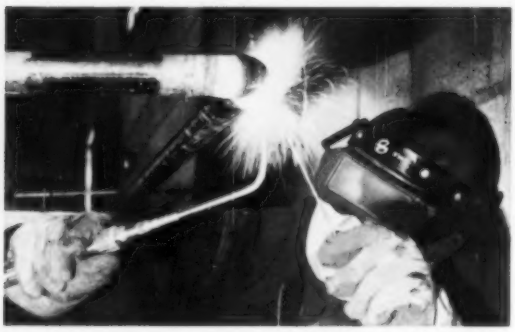


SAVES ON MATERIAL. Schedule 40 pipe, butt welded, is stronger in bending and fatigue and has greater thickness for corrosion resistance than Schedule 80, threaded. Hence, welding piping can be lighter . . . can cut material costs 30-50%.



SAVES ON INSTALLATION. Butt welded joints in 1½" piping, such as school heating line shown, averages 7 minutes compared to 8 minutes for threading and tightening fitting. Tools are simple, inexpensive.

SAVES ON MAINTENANCE. Butt welded joints are permanently as strong and leakproof as the pipe itself. Photo shows ½" welded water-heat piping for shopping center . . . specified to eliminate maintenance expense.

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IN CANADA: Tube Turns of Canada Limited, Ridgetown, Ontario
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A NEW CANADIAN OIL WELL SERVICE company has been formed by the coalition of two well-known Dominion firms—Thorson Oilfield Cementing, Ltd., and Strata Testers, Ltd.—and a leading United States service company, BJ Service, Inc. The new firm will be known as BJ Service of Canada Ltd.

Announcement of the new Canadian operation was made jointly by George M. Davis, president of the new firm, and John B. Merritt, executive vice president and general manager of BJ Service, Inc., Long Beach, California.

The Canadian company combines the capital, facilities and personnel of the Thorson and Strata Testers firms, with additional capital and technical support from BJ Service. Administrative offices will be located in Edmonton, Alberta, with a network of field stations throughout Canada's major oil and gas producing areas.

AN EXCLUSIVE LICENSING AGREEMENT has been concluded under which Elliott-Automation Limited, London, England, will manufacture and market certain analytical and control instruments of Consolidate Electrodynamics Corporation design.

The instruments include analytical and process-control mass spectrometers, chromatographs, moisture monitors, refractometers, and oxygen analyzers. Elliott-Automation experts to sell these instruments largely to the petroleum, chemical, and petrochemical industries.

A COMPLETE COMPANY STREAMLINING has been announced by Worthington Corporation.

Adoption of the new trademark follows by six years the abandonment of "Worthington Pump and Machinery Corporation" which had been its name for so many years. Today it is simply called the Worthington Corporation.

The emergence of a new marketing service wing of the Marketing Division under the supervision of Marketing vice president, T. J. Kehane, includes:

Product and Marketing Planning: Set up to help promote the use by the operating divisions of all needed marketing services both inside and outside the company.

Marketing Research: To get facts before taking action.

Advertising and Marketing Promotion: Brings advertising and sales promotion skills to bear not only on sales objectives, but also on other marketing objectives. Uses its communication skills and regular contact with divisions to help bring about a better understanding and practice of modern marketing principles.

▸ **Robert G. Allen** has been elected to the board of directors and the executive committee of Bucyrus-Ernie Co., South Milwaukee, Wisconsin. Allen's election was announced by W. L. Little, president of the company and cahirman of the board, following a meeting of the board at Bucyrus-Erie's new drill manufacturing plant at Richmond, Indiana.

Allen is executive vice president of Bucyrus-Erie in charge of all manufacturing and sales. He joined the company in July 1957 as a vice president.

Appointment of four persons to sales positions has been announced by the Drill Division, Bucyrus-Erie. They are: William G. Barnes, sales engineer—blast hole drills; Robert E. Cannon, service manager; Mark J. Janich, supervisor, parts and tools sales, and William G. Piper, supervisor, sales technical section.

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won't rust, chip
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There's no paint on Lufkin Chrome Clad "Atlas" Oil Gaging tape lines.

The bold, black markings are bonded to the basic metal . . . protected with several electroplatings that give extra strength to the line. The final metal coat is Lufkin's exclusive Chrome Clad finish. Glare-free, smooth, rust resistant . . . the most durable tape line you can buy.

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Engineered Products Sold with *Service*

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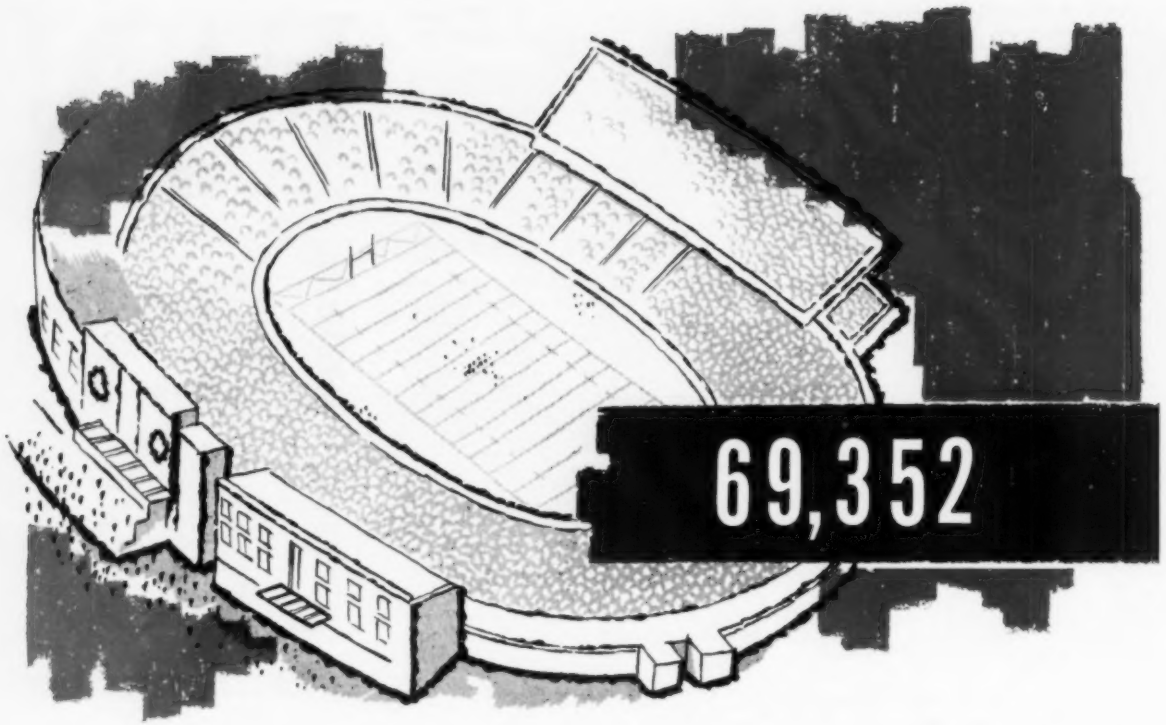

. . . Almost enough to fill the Cotton Bowl

That's the number of injured workmen who received medical aid and compensation benefits from Texas Employers' in 1957.

Of course, the thousands who were *not* injured because of the intense safety efforts of TEIA and its policyholders would fill many Cotton Bowls.

But when accidents do occur, it's doubly gratifying to know that your insurance carrier has trained and experienced men in 25 Texas offices who have the desire to handle your claims fairly and promptly.

This service is one of the principal reasons why TEIA writes more workmen's compensation insurance in Texas than any other *five* companies combined. Why not put this service to work for you? Call your nearest Texas Employers' office today.

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International Petroleum Exposition

May 14-23 **1959** • Tulsa, Oklahoma, U. S. A.

Night view of IPE with Tulsa Skyline

For Accommodations, write:
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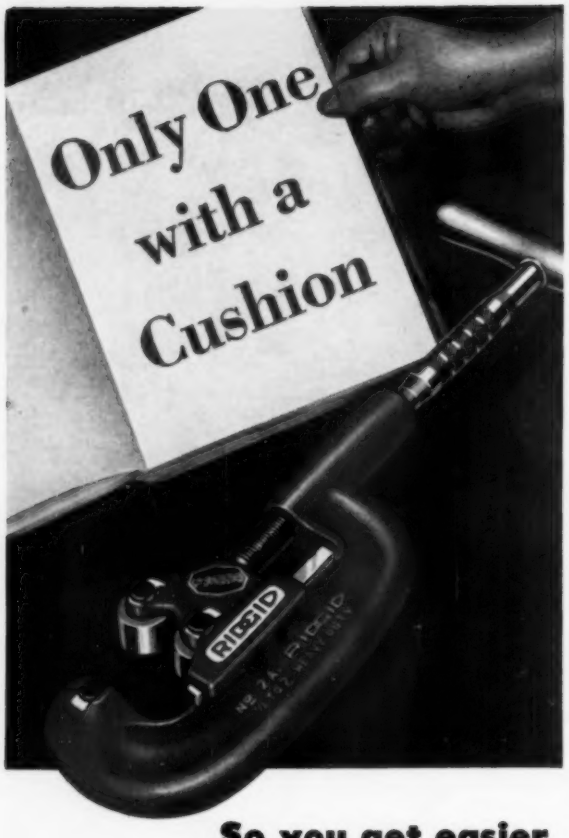
Wm. B. Way, General Manager

Dates of the IPE set in conjunction with World Petroleum Congress to be held in New York a week after the Tulsa Show

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



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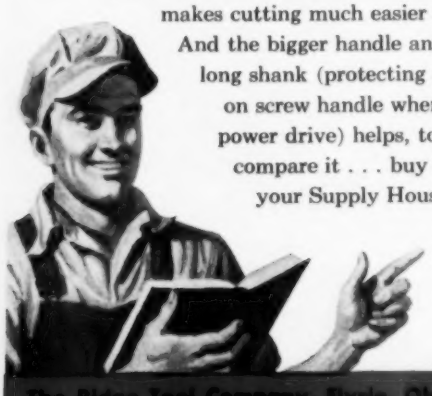
The instant you start feeding in this new cutter on a pipe you feel the remarkable difference, the new cushioning effect that makes cutting much easier and faster. And the bigger handle and extra long shank (protecting threads on screw handle when you use a power drive) helps, too. Try it, compare it . . . buy it at your Supply House.



The Ridge Tool Company, Elyria, Ohio, U. S. A.

NEW FACILITIES for Genesys Corporation have been completed in Los Angeles. Located at 10131 National Boulevard, the new modern brick structure contains 10,000 sq ft of floor area. Interior modifications resulted in functional development laboratory and manufacturing space for the engineering and product development staff. A complete micro machine shop is housed in a special dust-free laboratory devoted to the development of precision electromechanical components.

▸ **Graver Tank & Manufacturing Company, International Division,** has established an office in Caracas, Venezuela, W. Clark Root, president, announced. William I. Woodson has been appointed general manager.

The new South American office will enable Graver to offer its complete line of equipment, including large floating roof tanks, for sale and erection in Venezuela, Root said.

Woodson, a long-time resident in Venezuela, formerly served as manager of the Venezuelan Division of Texas Petroleum Company and also in Turkey as petroleum advisor to the Turkish government. He formerly resided in San Marcos, Texas.

Erwin C. Barnes, a Graver field engineer with wide overseas experience, was named as Woodson's assistant. The office is located at Edificio Central, Caracas, and mail inquiries originating in Venezuela should be sent to Apartado 2658, Caracas.

▸ **Dow Chemical Inter-American Ltd.** Appointment of Thomas G. Johnson as manager of the Buenos Aires, Argentina, sales office was announced. He will assist Dow Inter-American's representatives in Argentina, Bolivia, Chile, Ecuador, Paraguay, Peru and Uruguay in the sale of Dow products.

Before assignment to his new position, Johnson was assistant manager of the Montevideo office in Uruguay.

▸ **Hewitt-Robins, Inc.** William P. Kesel has been appointed export manager succeeding J. J. Murray, who continues as a consultant to the company.

Kesel began his career with Hewitt-Robins in 1939 as a trainee. In his new job of export manager, he will be responsible to J. J. Sheehan, manager of the company's international division.

▸ **Consolidated Electrodynamics Corporation.** Francis T. Greenup, formerly chief product engineer, was named manager of engineering services and manager of the Alectra department, which designs and manufactures CEC's Alectra line of portable test instruments.

George M. Slocomb, formerly supervisory principal engineer, was promoted to assistant chief development engineer, and E. James Penrose was named administrative manager. Penrose was formerly assistant to Joseph H. Lancor, Jr., vice president in charge of development.

▸ **Jones & Laughlin Supply Division.** C. J. (Jack) Jernigan, traffic manager has retired. He has been active in the transportation field for 48 years. He joined Jones & Laughlin Supply Division when it was Frick-Reid Supply Company in 1942 as assistant traffic manager.

▸ **Baroid Division National Lead Company** recently announced several appointments and transfers in its drilling mud department. Kemp S. Lewis, assistant manager of the Lower Texas Gulf Coast area, has been transferred to Corpus Christi, Texas. R. E. Killion, formerly sales representative in Houston, has been appointed district superintendent at McAllen, Texas. F. J. Wright, service engineer, was appointed store manager at Edinburg, Texas; W. W. Ames, service engineer, was appointed store manager at Corpus Christi; Jay Crist has been employed as store manager at Jourdanton; and June Wallace employed as store manager at Tyler, Texas.

In West Texas, John T. Blaney, Jr., formerly district superintendent at Abilene, has been appointed assistant area manager and will remain at Abilene. He is replaced as district superintendent by Ed L. Easley, formerly district superintendent at Wichita Falls. J. D. Newsom, district sales representative, replaces Easley as district superintendent at Wichita Falls.

In the Rocky Mountain area, Store Manager E. A. Fine, Jr., has been appointed district superintendent with headquarters in Williston, North Dakota, and F. M. Estep appointed district sales representative with headquarters at Billings, Montana.

In the Louisiana Gulf Coast area, H. J. Thompson, service

engineer, was appointed store manager at Shreveport, and will be responsible for stores at Zwolle, Minden and Cotton Valley. G. G. Moles, service engineer, was appointed store manager at Homer and will also manage Baroid stores at Ruston, Arcadia, and Bernice, Louisiana.

S. E. Marrs, sales representative, at Lafayette, was appointed store manager at Monroe and will also be responsible for Baroid stores at Delhi and Winnsboro, Louisiana.

J. Lamar Smith, Jr., sales engineer, has been transferred from Lafayette to Magnolia, Arkansas, as store manager. He will also manage stores at Lewisville and El Dorado, Arkansas.

J. W. Wheat, sales representative, was transferred from Lake Charles, Louisiana, to Jackson, Mississippi. P. E. Silver, service engineer, was transferred from Lake Charles and appointed store manager at Brookhaven, Mississippi. J. A. Conway, service engineer at Lake Charles was appointed store manager at Natchez, Mississippi, and will also be responsible for the Port Gibson Store.

Sam Hailey, formerly of Sam Hailey Mud and Chemical Company, has been employed as store manager at Canton, Mississippi.

▸ **Monsanto Chemical Company.** Election of Patrick J. Dowd of St. Louis to the position of treasurer was announced. Dowd has been director of administration for the company's Overseas Division. He succeeds Edward D. Toland Jr., also of St. Louis, who has resigned.

▸ **M. W. Kellogg Company** (Pullman Inc.). Dr. John W. Kraus was appointed research chemist. Dr. Kraus, who was formerly with the Argonne National Laboratories, will be engaged in mass spectrometry at M. W. Kellogg. His appointment is part of the firm's expanded research and development program under the supervision of Dr. Alex G. Oblad, Kellogg vice president.

▸ **Garrett Oil Tools, Inc.** (Division of U.S. Industries). Appointment of Bolling A. Abercrombie as assistant to the vice president-engineering has been announced. Abercrombie, who has been serving as a sales engineer in the company's Houston District, has moved to Garrett's home office at Longview, Texas. He joined Garrett Oil Tools, Inc., in October, 1955. Prior to that time, he worked with Texas Pipeline Company in Tulsa, Lockwood & Andrews in Houston, and J. S. Abercrombie in Gonzales, Texas.

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A-2 More Interest on Your Training Dollar — *Carl Mullins White*
A-3 Industrial Relations in the Oil Industry — *Ray O. Weems Jr.*
A-4 Instruments and Control Equipment Directory for the Petroleum Industry
A-5 How to Write Better Technical Articles — *John L. Kent*
A-6 What Makes a Man Work? — *A. Q. Sartain*
A-7 You Can Buy It in S. A.—Directory of Supply and Service Companies in S. A.
A-8 Percentage Depletion — Hardly Anybody Understands It
A-9 Management's Real Job — PROFITS — *Edward J. Burnell*
A-10 How to Reduce Costs — *Benjamin P. Hamilton, Jr.*
A-11 12th Annual Report Survey — *Ernestine Adams*
A-12 Secrets May Be Stumbling Block

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Now you thread 4", 4½", 5" and 6" pipe with only One set of dies with the New RIDGID No. 161 4" to 6" Geared Pipe Threader

Check These Time-Saving Features:

1. **Jam-Proof** for safe threading by power or hand. Drive pinion kicks out automatically when full thread is cut. Die head can't jam.

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The Ridge Tool Company, Elyria, Ohio, U.S.A.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Trade Parade

Radio Corporation of America. R. E. Wilson has been named manager, communications manufacturing. He will direct the manufacturing activities of "Radiomarine," microwave and mobile communications equipment from his office at Camden, New Jersey.

Catalytic Construction Company. James K. Logan was appointed manager of the Middle Atlantic area and will work out of the main office in Philadelphia. Logan has had 15 years experience in design and construction of processing plants.

Bucyrus-Erie Company. Charles Parthum, formerly with Harnischfeger Corporation, Milwaukee, where he had been director of public relations, sales promotion and advertising, was named sales promotion manager.

Brown Oil Tools, Inc. Woodrow Heard was promoted to works manager where he will have direct supervision of all manufacturing facilities, shop personnel, shop requirements of materials and supplies, and tool engineering.

Furniss M. Prell, who has had extensive experience in oilfield equipment sales and installation, as salesman for Metropolitan Houston. Prell was active in drilling activity, beginning as a roughneck and advancing to district superintendent for the Shell Oil Company. Before joining Brown, he was a district manager for the A-1 Bit and Tool Company and for Garrett Oil Tools.

ACF Industries. L. Rene Gaiennie has been elected vice president of industrial and public relations. He succeeds Albert L. Kress, who remains a staff vice president. Gaiennie came to ACF in September, 1957 as director of industrial and public relations. His new duties will encompass labor relations, public relations, personnel, wage and salary administration, security, safety and employee benefits.

American Cyanamid Company. A. J. Weith Jr., commercial development manager for the organic chemicals division became industry advisor to the Chemical and Rubber Division of the Business and Defense Services Administration, U. S. Commerce Department in Washington, D. C.

Baker Oil Tools. Paul E. Hilton was elected to the board of directors to fill the vacancy created by the death of Roy W. Henderson. Hilton, who will continue as manager of central division sales and service, Houston, Texas, was also elected a vice president.

Baroid Division National Lead Company. R. E. Souther is new manager of foreign operations. He has been with Baroid for 19 years, having served as chief engineer of well logging department, manager equipment department, and manager of the well logging department. Souther will be responsible for Baroid's export department and coordination with overseas affiliates.

Replacing him as manager of the well logging department is B. O. Pixler, formerly assistant manager. Pixler has been with Baroid since 1940, having served with the company throughout the entire United States.

S. E. Geffen has been appointed area superintendent of logging department in Denver, Colorado, replacing Wendell H. Russell, who has returned to Houston as assistant manager of the department.

In the drilling mud department, H. I. Bussa, formerly assistant manager of the Lower Texas Gulf Coast area office, has been appointed administrative assistant to the manager. Replacing him is Kemp S. Lewis.

B. F. Stiba, formerly sales representative in the East Louisiana Area, has been appointed sales manager in the Lower Texas Gulf Coast area with headquarters in Houston.

The J. B. Beaird Company. Melvin A. Finuf, manager of sales since May 1957 has been elevated to the staff of the executive vice president as marketing assistant. Climaxing 23 years of broad experience in sales, engineering and production at Beaird, Finuf will perform a key staff role in the planning and execution of the company's long range program of market expansion.

Finuf joined Beaird in 1935, and transferred to sales nearly 15 years ago as tank divisional sales manager. He subsequently served as assistant sales manager and assistant general sales manager.

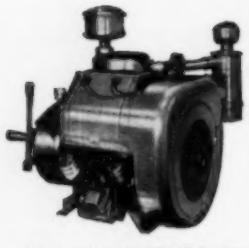
Gerald Pope, assistant ganeral sales manager of sales, has been named to succeed Finuf.

Black, Sivalls & Bryson, Inc. M. Steve Worley has been promoted to chief development engineer for the Oilfield Equipment Division, Oklahoma City. Worley joined BS&B in 1951 upon receiving an MS, became product supervisor for dehydrators and desulfurizers in 1952, later became project supervisor in the development group.

Charles R. Bootz is new manager of its Controls Division, Tulsa. He has been with BS&B almost two years as manager of the company's nuclear project. Prior to joining BS&B he was director of laboratories of Rand Development Corporation.

Judge your power unit by its

LUGGING FACTOR!



Model VR4D 56 hp

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heavy duty Air-Cooled
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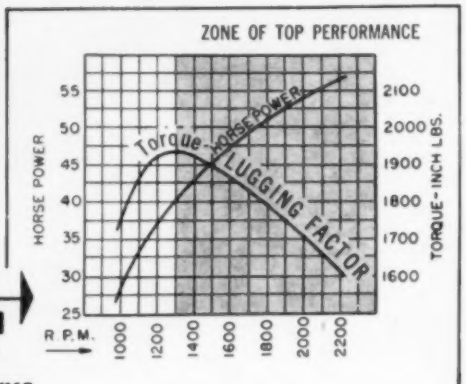

When the power load suddenly *builds up* and the engine speed *slows down* . . . how long will the engine *hang on* and carry the increased load without stalling?

The answer lies in the HIGH TORQUE LUGGING FACTOR which is an integral part of "Wisconsin" basic engineering. The point at which an engine will stall under suddenly increased loads is the *High Point* in the TORQUE CURVE. As a case in point, analyze the Wisconsin Model VR4D power curves reproduced here.

This engine develops its maximum horsepower (56 hp.) at 2200 rpm. at which point it registers a torque of 1600 inch-lbs. The engine runs into heavy going. The load builds up fast. The rpm. slows down to 2000, 1800, 1600 and 1400 rpm., reaching its maximum torque *at the low speed* of 1300 rpm.

In terms of power service to the user, this simply means that your Wisconsin Engine is designed *to provide dependable load-holding power at low engine speeds.* This, in turn, means fewer shutdowns, less wear and tear, more usable power and more versatile performance for your dollar investment.

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Books to Read

Proceedings of The Fifth Annual West Texas Oil Lifting Short Course, *published by Texas Technological College, Petroleum Engineering Department, Lubbock, Texas. Pages, 249. Price, $7.50.*

This manual includes 42 pages on artificial lift that were presented at the West Texas Oil Lifting Short Course in April 1957. It includes drawings, charts and photographs explaining the various subjects. In addition, a panel discussion on automatic custody transfer is also in the book; also includes the opening session address, "Where Will Present Production Trends Take Us?" by Charles W. Alcorn, president of the Texas Mid-Continent Oil & Gas Association.

Bibliography of Theses in Geology, *compiled by John Chronic and Halka Chronic, published by Pruett Press, Inc., 1942 20th Street, Boulder, Colorado. Price $15.*

This bibliography includes descriptive titles of more than 11,000 theses prepared in colleges and universities of the U. S. and Canada. Each entry lists the name of the author, the date, and the university where the thesis is kept. There is an index classifying the theses by geographic location, as well as by geologic time and subject matter. Subject matter is the theses range from geophysics, geochemistry, geological engineering and petroleum engineering. Mining theses are also included when their titles indicate any aspect of geology is discussed.

Petroleum-Prehistoric to Petrochemicals, *published by McGraw-Hill, 327 West 41st Street, New York 36, New York. Pages, 500. Price, $15.*

This volume traces development of oil from geological and archaeological beginnings to present day products in an effort to provide an authoritative, standard reference on the technology and products of petroleum. Such topics as the occurrence of petroleum, searching, drilling, production, distillation, product control, gases and solvents, fuels, lubricants, waxes, asphalts, and petrochemicals are covered in various chapters. Specific refining operation for each of the major products are taken up in detail.

Oil and Gas Field Development in United States and Canada, 1958 Year Book, *published by National Oil Scouts & Landmen's Association, P. O. Box 1095, Austin 66, Texas. Pages, 1136. Price, $12.*

This is an annual review of geological and geophysical prospecting, land and leasing activities, wildcat exploration, proven field development, oil and gas production, pipeline and refinery statistics. The book this year includes a section on Alaska for the first time. It also includes sections on 33 states and three Canadian provinces. George B. Ross, editor-in-chief of this edition, is assistant division scout in Midland, Texas for Humble Oil & Refining Company. He heads the list of 49 other scout-editors and contributors in gathering the 1957 information.

Research Study of Shut-In Gas Wells in Railroad Commission Districts 1, 2, 3 and 4, *published by Austin Oil and Gas Publishing Company, P. O. Box 5146, West Austin Station, Austin, Texas. Price, $80.*

This listing of shut-in gas wells in about half of Texas is a compilation drawn from the records of the Railroad Commission of Texas. Material on the Texas Gulf Coast area was assembled from some 25,000 ledger sheets, standardized and indexed as reported through December 31, 1957. Approximately 3000 shut-in gas wells are listed. Information includes RRC district, county, field, operator, lease, well number, survey, date of completion, perforation interval, formation or reservoir tops, pressures, gravity of gas, and potential test.

Drilling and Production Practice (1957), *compiled by American Petroleum Institute, Division of Production, 300 Corrigan Tower Building, Dallas 1, Texas. Pages, 350. Price postpaid, $6; for foreign shipment $6.25.*

The cloth-bound volume contains 27 papers, specially selected from those presented during 1957 at Division of Production API district meetings and annual-meeting group sessions. A bibliography of all presented at district meetings is included. This presentation is the most recent of the yearly-published volumes dating from 1935.

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Newly developed Spunline Process... a combination of the world famous Tate and centrifugal processes... is now available for cement mortar lining of 6" to 16" diameter pipes "in place." Permits application of thinner lining with closer tolerance... permits lining past smaller openings and corporation stops... through many bends and certain fittings. Particularly advantageous with cast iron pipe... restores flow coefficients, protects against corrosion, contamination. *Write today for full information.*

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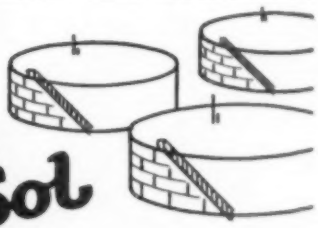

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The money you make on reclaimed tank bottoms by using BRAKESOL will be substantially more than the cost of treating . . . including chemical and labor. Safe for use in production, pipeline and refinery equipment . . . Contains no chlorides, sulphides or other halides. BRAKESOL Treating Engineers have the experience and know-how to do a successful job. Contact them now!

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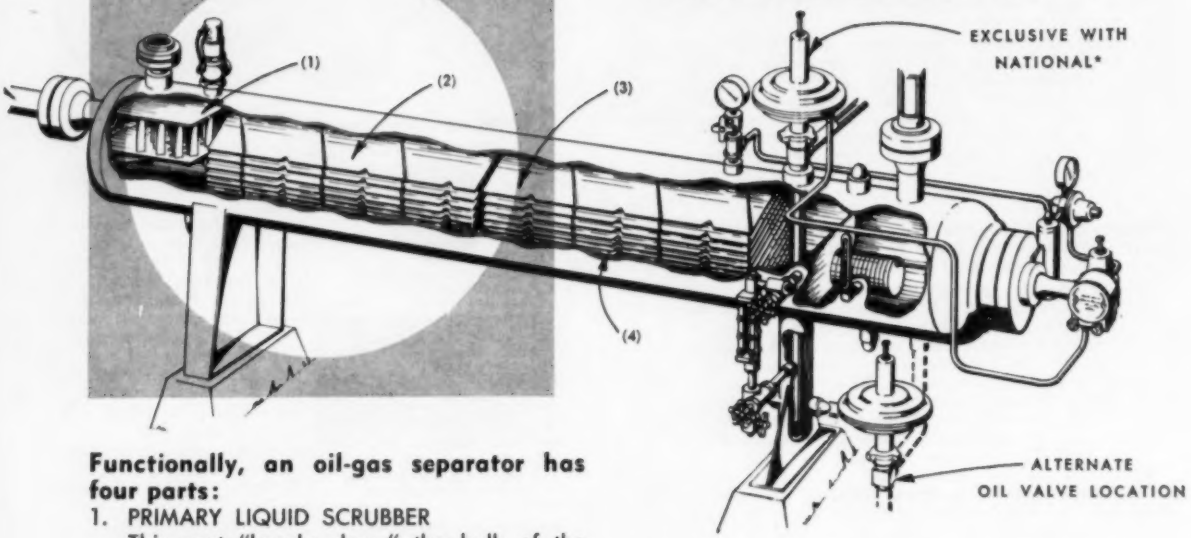

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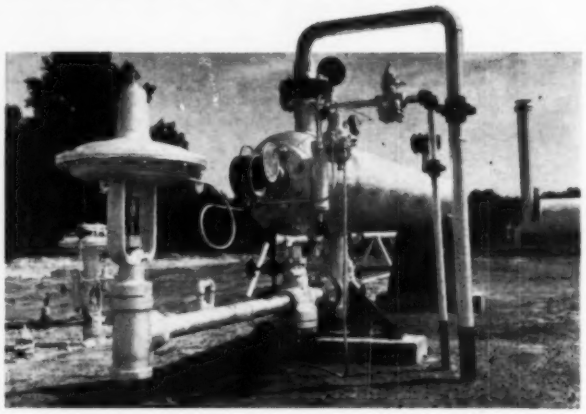
   This part "knocks down" the bulk of the liquid and removes it from the flowing gas stream immediately.
   National's present design is the result of field tests using full scale operational models which utilized numerous scrubbing elements. From these tests National's present design was found. Today, when you buy a National MONOTUBE Separator, you buy experience, not experimentation.
2. MAIN GAS SCRUBBER
   Also as a result of these tests, proper spacing and length of Main Gas Scrubber plates was discovered, so as to effect the greatest liquid removal from the gas stream.
3. FINAL GAS SCRUBBING
   The multiple field tests with flanged components dictated our design. National's "straight-vane" design accomplishes final liquid removal without the use of "excelsior-like" elements which are prone to be plugged with waxes, sands and other extraneous materials, including hydrates inherent in the normal oil-gas and distillate production operations.
4. OIL DE-GASSING COMPARTMENT
   What effects oil de-gassing? (a) Length of time in compartment. (b) Surface area of oil body. (c) Scrubbing surfaces to remove entrained gases. When (a), (b) and (c) are at a maximum, oil de-gassing is best. National's full-scale field testing found the proper ratios.



***EXCLUSIVE WITH NATIONAL!**

A field-proven, non-freeze liquid valve, particularly useful on high gas-oil ratio wells where entrance temperatures are near hydrate point. Ask your National man about this exclusive feature.

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

the Petroleum Engineer

Exploration
Drilling
Producing

Good equipment

.....PLUS A GOOD CREW

MAKES CUSTOMERS

Satisfied customers are the greatest asset a well servicing contractor can have — particularly when times are rough and many yards are full of units. Good equipment, plus good crews, is one of the most important ingredients in gaining satisfied and repeat customers.

Franks pole mast units have a high preference among oil companies as units they like to have servicing their wells. Franks Cruisers are noted for simplicity, convenience, and rugged dependability.

They inspire crews to work fast, safely, and get a satisfactory job done for your customers.

Franks Cruisers obtainable in models 2,500 to 12,000 ft. Single or double drum, single or double pole mast.

There's a Franks model best fitted for your individual work. Franks representatives will be happy to discuss this with you. Or write for a Franks catalog.

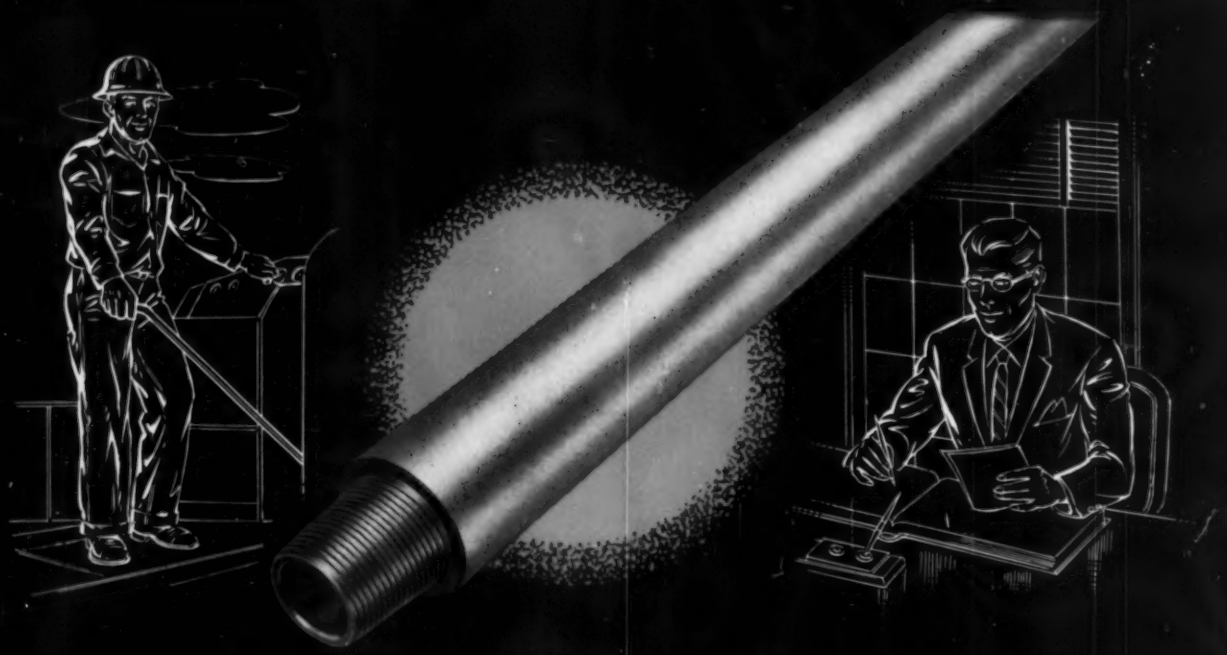
WELL SERVICING AND DRILLING UNITS

FRANKS

DIVISION OF

CABOT

PAMPA, TEXAS



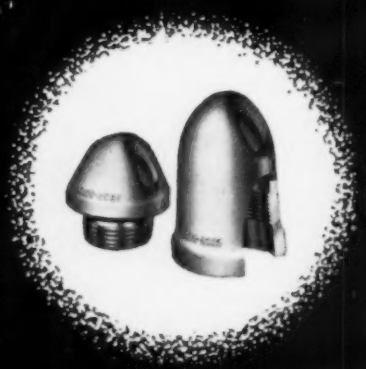
your driller and your accountant....
both of 'em like

BAASH-ROSS
Drill Collars

● Your cost accountant likes the **savings** shown by the consistent long service life of Baash-Ross drill collars, while your driller appreciates the extra margin of safety and dependability in Baash-Ross collars that keeps his string "turning to the right."

● Laboratory developed and field tested alloy steels are forged, turned, bored, threaded and heat treated under the most exacting of specifications and conditions to produce drill collars of outstanding quality. You can rely on your Baash-Ross drill collars to have perfect balance, accurately mating connections and the optimum combination of hardness, tensile strength and stiffness to meet every down-hole job requirement.

● Add to your drilling profits, order your next drill collar string from Baash-Ross. You will find Baash-Ross representatives in every oil producing area in the free world.



BAASH-ROSS Lifting Type Thread Protectors positively protect drill collar threads and shoulders while in storage or transit and the strong built-in bail with the rounded "glide" greatly simplifies drill collar handling at the rig. Box and pin units screw together for convenient storage.

For full information see Composite Catalog or write Dept. C-10, P. O. Box 1348, Houston 1, Texas

BAASH-ROSS DIVISION
OF JOY MANUFACTURING COMPANY

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Houston, Texas; Odessa, Texas; Dallas, Texas; Long Beach, Calif.; Denver, Colo.; Oklahoma City, Okla.; Olney, Ill.; Mexico City, Mexico; Edmonton, Alberta, Canada.

FOREIGN OFFICES:
New York, N. Y.; Greenock, Scotland; London, England; Paris, France; Maracaibo, Venezuela; Buenos Aires, Argentina.

BAASH ROSS JOY

Single or double drum, single or double pole mast.

Of Things To Come . . . In Oil

THE SEARCH FOR ALASKAN OIL will be a long one, says Humble's President Morgan J. Davis. Preliminary geological investigations place total oil-favorable lands between 100 and 130 million acres. Humble, who has been "prospecting" in Alaska since 1953, points out that exploratory development will take time. Davis says his company is not entering on a short-term basis and would not "pull out if our first ventures prove unsuccessful . . . Other oil companies . . . feel the same way."

DRILLING CONTRACTORS ARE NOT OVER THE HUMP — and won't be for two or three years, according to PETROLEUM ENGINEER survey of contractors' own predictions. Most contend that "good times" won't return until those "who can't count the costs" are weeded from the field. Most contractors foresee a brighter horizon in 1960, with lighter and more mobile rigs and with lots more air/gas and slim hole drilling.

AIR/GAS DRILLING MAY NOW BE CONSIDERED in new areas and to greater depths — previously ruled out because of marginal water flows. Formation sealers such as polymeric water gels, resins and resin slurries, alum-ammonia precipitates will find increased usage as treatment costs decrease. Several new lines of chemicals will permit living with moderate amounts of formation water. These include water-absorbing agents (silica gels), waterproofing agents (metallic stearates), and foaming agents (detergents). Detergents now permit continued air drilling with as much as 40 bbl per hr of clear water influx, or 10 bbl of saturated salt water, or 2 bbl of oil.

GREATER PROMOTION POSSIBILITIES are a certainty for technical personnel in major oil company research and engineering departments, thanks to "technical job progression" plans being adopted. Recognition of outstanding technical personnel is to be on par with that in administrative field. Conoco is instituting plan giving new titles to certain personnel in Conoco's headquarters manufacturing and engineering departments, such as: Senior consultant, senior adviser, consultant and adviser.

WILMINGTON FIELD SUBSIDENCE SUIT will not be cancelled by the Navy — and government spokesmen say it will try to collect damages estimated at $15,000,000. Some 120 operators involved in the subsidence area in Long Beach, California, are working toward prompt, voluntary repressurization plan. Department of Justice, handling the case, indicates that nothing short of shutdown injunction power, coupled with continuous and complete corrective measures would be satisfactory.

Location shot of Norwood's efficient HP-18000 Wheland Pump. Mr. Alan Norwood, Co-Owner of Norwood Drilling Co. is shown at left; at right, Wheland representative A. B. Drake.

PERFORMANCE!

". . . has fully met our expectations on performance . . ."

"have had no expense on this pump"

WHELAND HP-18000

DUPLEX SLUSH PUMP

7¾" x 18", 750 HP Nominal Input at 60 RPM.
Discharge Pressure with 7¾" liner, 1322 PSI;
Discharge Pressure with 5½" liner, 2700 PSI.

BULLETIN ON REQUEST

NORWOOD DRILLING CO.
WICHITA NATIONAL BUILDING
WICHITA FALLS, TEXAS

January 21, 1958

Mr. Gordon P. Street
The Wheland Company
Signal Mountain Road
Chattanooga, Tennessee

Dear Mr. Street:

We operate six rigs in West Texas and New Mexico area; depths range from 5,000 feet to 14,000 feet.

The Wheland HP-18000 pump we bought more than a year ago has been in the West Texas area working on wells between 10,500 feet and 13,500 feet. It has fully met our expectations on performance and so far we have had no expense on this pump.

Yours very truly,

NORWOOD DRILLING COMPANY

By: Alan Norwood
Alan Norwood

WHELAND

ROTARY DRILLING MACHINERY

THE WHELAND COMPANY
CHATTANOOGA, TENNESSEE, U.S.A.

DRAW WORKS • SLUSH PUMPS • ROTARIES
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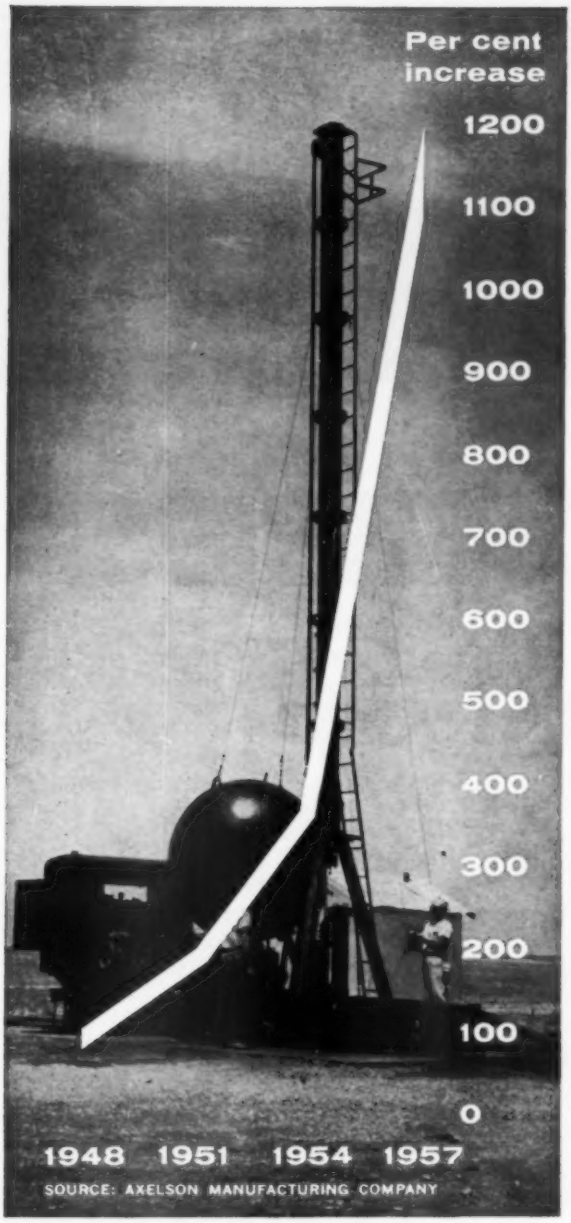

BIG GAINS FOR HYDRAX UNITS

Axelson Hydrax Use Shows 10-year Record Growth

Here's why:

- Vastly improved volumetric efficiency
- Sucker rod life extended as much as eight times
- Rod stresses safely increased as much as 30%
- Gas lock eliminated by high compression ratios
- Less wear and tear on subsurface pumps
- Less turbulence at well bottom
- Simple to install.

HYDRAX units are backed by a factory-trained service organization.

Write for HYDRAX brochure

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Since 1898 products designed to give oil a lift

There is no economical substitute for quality.

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AXELSON PRODUCTS ARE DISTRIBUTED EVERYWHERE

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Representatives in Odessa, Wichita Falls, and Oklahoma City

FOREIGN: Representatives in all major oil producing areas.

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Your Baroid engineer knows how to obtain the optimum filtrate volume and best filtrate properties for the job while maintaining the other mud properties in proper balance. You get the *best* results when you use Baroid's modern products, techniques and know-how!

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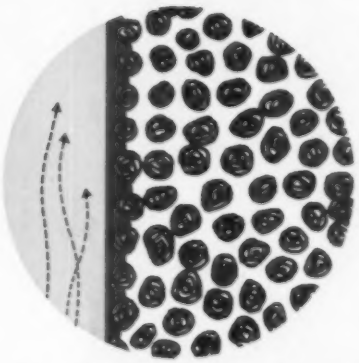

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GOOD COMPLETION

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STABLE AGGREGATED MUD

STABLE DEFLOCCULATED MUD

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CF&I SEAMLESS casing and tubing AP

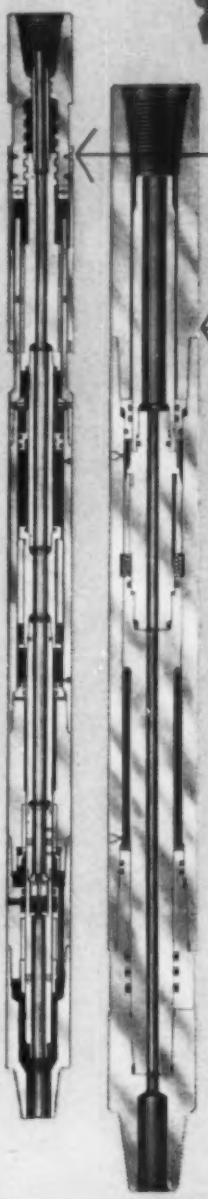
THE COLORADO FUEL AND IRON CORPORATION • DENVER, COLORADO

FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

SHARE

in

the tool the test designed

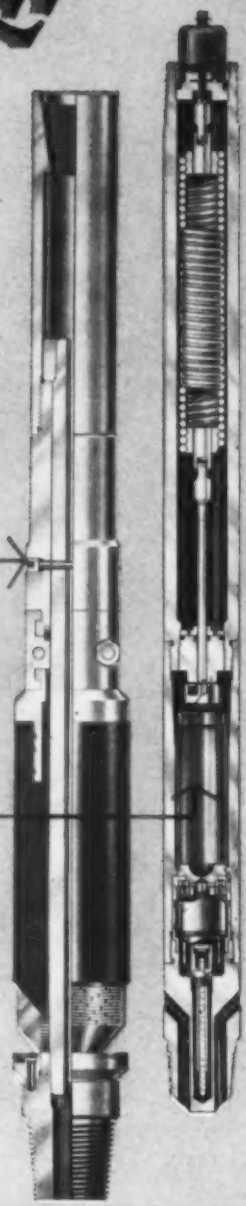


The Johnston Shut-In Hydraulic Tester. **Designed for positive operation under a wide range of testing conditions. One-piece construction means quicker "make-up" and "break-down" saving valuable rig time.**

The newest Johnston Jar, the Type HS-1 Hydraulic Jar, **answered the needs dictated by drill stem testing operations. More jarring action from this "easy to maintain" tool. Shorter for "easier handling" and faster "make-up." Designed to consistently deliver and withstand innumerable shocking blows.**

The Johnston Bob-Tail Packer. **Its design features a reduction of the necessary rubber diameter while assuring a completely effective seal. The increased by-pass area improves running characteristics and speeds up running and pulling time. In washed-out or out-of-gauge holes a larger packer and packing element gives the same advantages.**

Johnston Type "T" Pressure Recorder. **Unfailing accuracy, sensitivity and dependability under all types of formation testing conditions. Extensive laboratory and field tests proved the Johnston Tension Type recorder to be more accurate and consistently dependable under all conditions.**



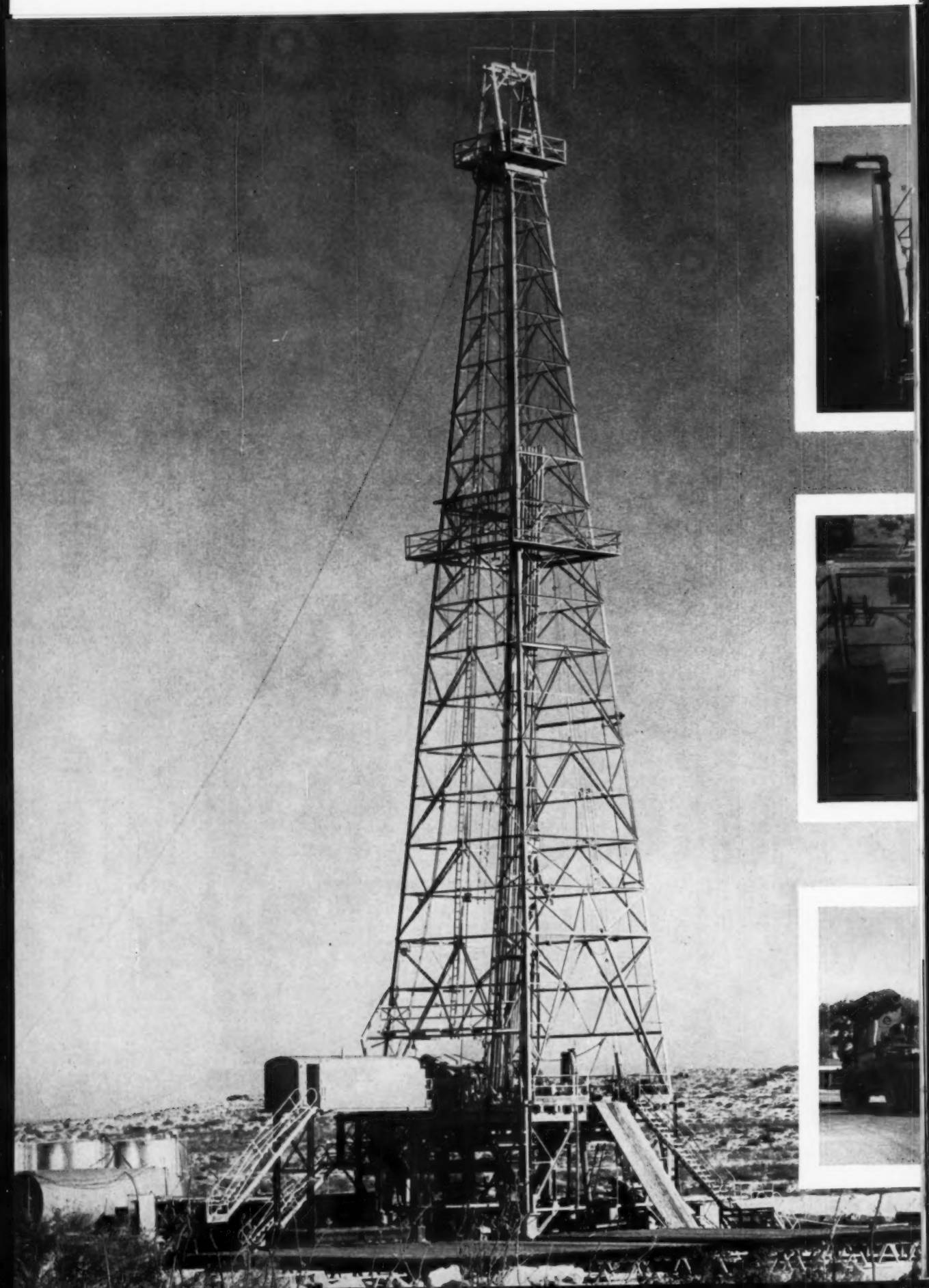
Rely on Johnston for all your drill stem test needs always. Johnston Testers, Inc., Houston, Texas; Long Beach, California; Calgary, Alberta, Canada. Export Sales Office, Houston, Texas.

A WORLD OF EXPERIENCE

JOHNSTON TESTERS

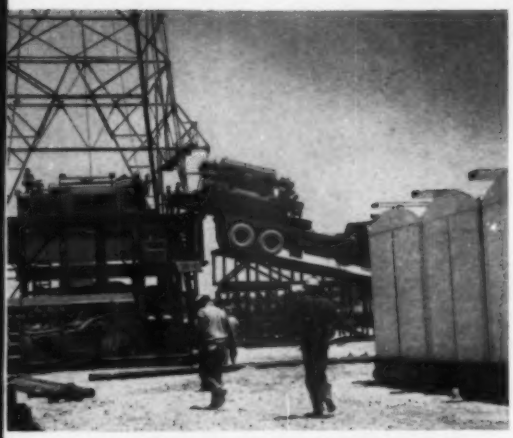
Johnston's thirty years of manufacturing and testing know-how is easily recognized in The Tool The Test Designed. Each piece of Johnston equipment is designed to meet the requirements of the test under all types of well conditions.

FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Great Western Drilling Company reports . . .

G-E Equipped Rig Drills 23,000 Feet in 364 Days!



RIG-UP TOOK ONLY 3 DAYS, including 125-mile move. Time-consuming mechanical alignment is eliminated with electric drive's flexible cable connections.

POSITIVE, SIMPLE CONTROL enables GW drillers to drill more hole at less cost. G.E.'s low maintenance drive system reduces down-time to a bare minimum.

G-E DRIVE'S PORTABILITY is demonstrated by move time required from Odessa to Ft. Stockton—half that needed for comparable mechanical rig.

GW's Diesel-Electric Rig 44 Handles 600,000-pound Net Hook Load Setting Record 15,868 Feet of 9 5/8-inch Casing

GREAT WESTERN'S G-E EQUIPPED RIG HAS SET RECORDS even before completion of one of the world's deepest holes. At Phillips Petroleum & Sinclair Oil Company's No. 1-A Montgomery in Pecos County, Texas, a record string of 15,868 feet of 9⅝-inch casing was recently set. To accomplish this, the rig handled a net hook load of 600,000 pounds, one of the heaviest known loads ever encountered.

ALMOST SIX MONTHS AHEAD OF THE ORIGINAL DRILLING SCHEDULE, Great Western has experienced no significant loss of time due to electrical failure or maintenance. The dependability of the General Electric Drive System has kept down-time to a bare minimum and its inherent advantages have enabled Great Western to drill more hole at less cost.

FOR MORE INFORMATION ABOUT GENERAL ELECTRIC DRIVE, call your nearest G-E Apparatus Sales Office. Drilling offices are located in Dallas, Denver, Houston, Los Angeles, New Orleans, and Tulsa; in Canada: Calgary and Toronto. For overseas requirements, International General Electric drilling offices are located in Bogota, Buenos Aires, Caracas, Maracaibo, Mexico City, New York, and Puerto LaCruz. General Electric Company, Locomotive and Car Equipment Department, Erie, Pennsylvania.

115-26

Progress Is Our Most Important Product

GENERAL ELECTRIC

"POWER CHIEF® gas engines have given us over 40,000 hours of continuous pumping with only minor maintenance"

. . . say many of the oil men who have had first-hand experience with these rugged production pumping engines. Actual operating costs have proved that these heavy-duty, medium-speed Nordberg gas engines consistently establish records of reliability and low maintenance. Records often show over 40,000 hours of continuous pumping operation with original rings, pistons, liners, valves, bearings and crankshafts still in place.

Power Chief Gas Engines in 1 and 2-cylinder models deliver up to 36 hp maximum rating. *Power Chief* Diesel Generator Sets, available with special vibration mountings, produce 5 to 30 kw for continuous service.

For full details, write for Bulletin 268.

Reasons why *Power Chief* engines are your best buy:

- CONSERVATIVE RATINGS
- SMOOTH, STEADY OPERATION IN ANY WEATHER
- EASY TO START
- EASY TO SERVICE IN THE FIELD
- MORE "EXTRAS" AS STANDARD EQUIPMENT
- SAFEST ENGINE IN THE FIELD
- PARTS AND SERVICE READILY AVAILABLE
- OPERATE ON SOUR GAS
- HEAVY-DUTY CONSTRUCTION THROUGHOUT

NORDBERG MFG. CO., Milwaukee 1, Wisconsin

NORDBERG ..... POWER CHIEF

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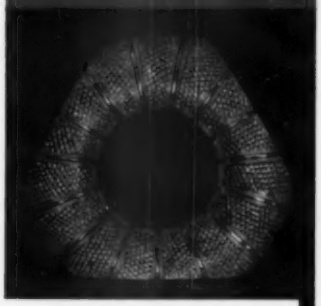

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WRITE OR CALL TODAY!
for complete information and locations of D&S sales-engineers. They will be happy to explain our custom bits and services.

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Ultra Fine Diamond Equipment for the Oilfield

D&S *diamond* CORE BITS ARE VITAL TO...

- Determine porosity in detail.
- Pin-point the pay zone permeability.
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- Aid in electric logging interpretation.
- Help you pre-determine well completion zones.
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- Selective Acidizing.
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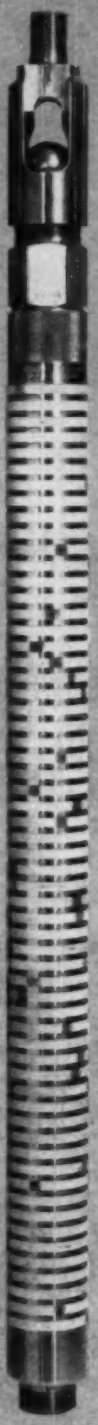
- Assure you of accuracy in all types of formations.

Specify TRI-DIA for fastest diamond coring!

Metal to Metal Wear...

is the real villain in sucker rod pump troubles. It accounts for most of your repair and pump pulling expense.



The Martin Idea...

for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

Patent No. 2,591,174

The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

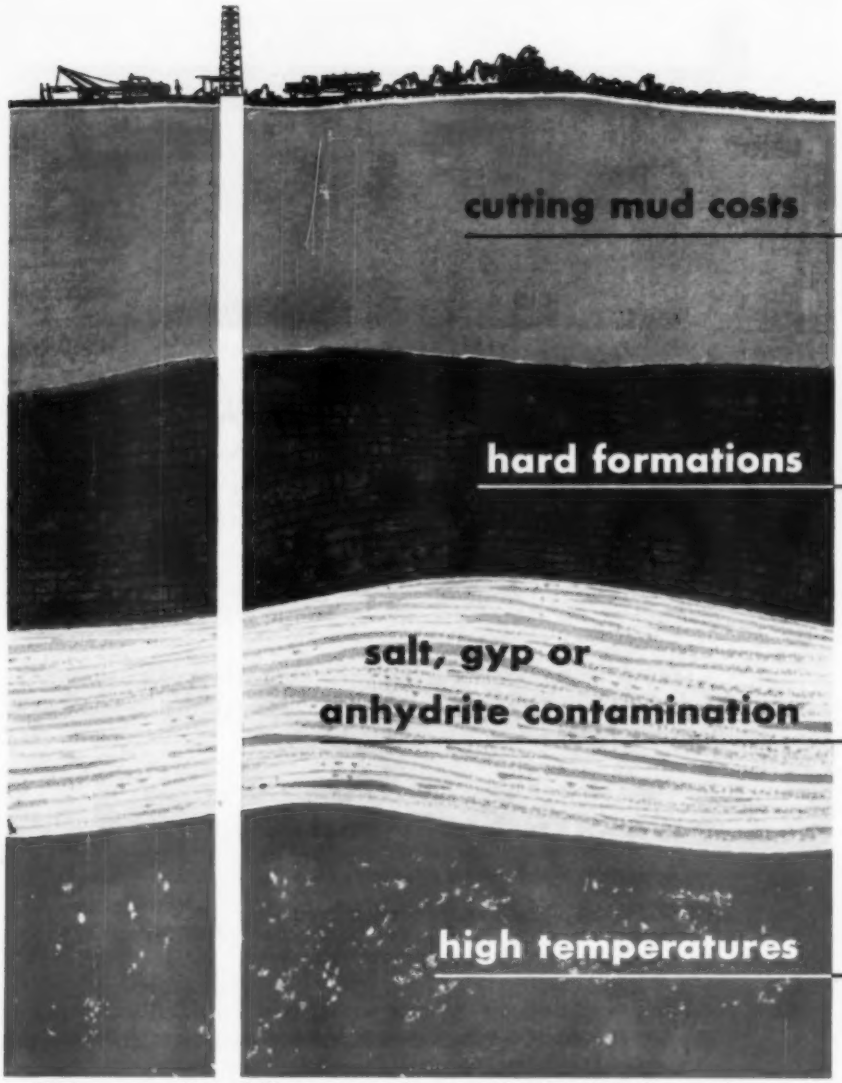
No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

JOHN N. MARTIN

Manufacturer

9 W. BRADY • TULSA, OKLA.



Du Pont CMC (Grade DM) costs less than highly purified grades which exceed most drilling needs. Without the premium price, you get excellent fluid loss control, good weight suspending properties.

For a good oil-in-water, low solids mud, use a little Du Pont *high viscosity* CMC in place of a lot of bentonite. By holding clay solids to a minimum, you get a "fast drilling" mud which requires a minimum of chemical treatment.

When Du Pont CMC is used as a clay replacement, the undesirable effects normally resulting from an encounter with salt, gyp, or anhydrite, are minimized. Costly rig time for mud conditioning is reduced.

Your muds hold up, even at extreme depths, when you use Du Pont CMC because of its resistance to thermal and bacterial degradation.

Offshore or onshore, drillers report saving as much as 50% in dollars-per-foot costs by using Du Pont CMC in their muds.

How Du Pont CMC solves these mud problems ...at rock-bottom cost

DU PONT
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DU PONT CMC
FOR DRILLING MUDS

Better Things for Better Living . . . through Chemistry

Your local mud dealer can introduce you to these and other advantages of Du Pont CMC (low viscosity or high viscosity) **immediately.** Or contact:

- **Barada & Page, Inc.,** offices in Corpus Christi, Dallas, Fort Worth, Houston, Kansas City, New Orleans, Odessa, Oklahoma City, Tulsa, Wichita.
- **Macco Corp.,** Paramount, California.
- **Du Pont Explosives Department,** offices in Dallas, Los Angeles and Wilmington.

See the "Du Pont Show of the Month" on CBS

"WELL DESIGNED" FOR REMEDIAL PROBLEMS

HALLIBURTON SQUEEZE CEMENTING

Variable conditions in down-hole trouble spots require especially designed cement slurries and applications, to aid in the correction of these problems.

Halliburton Squeeze Cementing has been the answer for well owners in the selection of the proper solution for many years for many of these frequent problems:

- Repair of casing leaks
- Isolation of producing zones prior to perforation
- Correction of channeling problems
- Sealing off of low pressure thieving formations
- Abandonment of depleted producing zones

For a "well designed" squeeze job for your individual well requirements... backed-up by unmatched experience, equipment and materials ... specify Halliburton Squeeze Cementing, you'll save time, money and worry.

"DM-DC" Drillable Squeeze Packer

HALLIBURTON COMBINES...

TOOLS and TECHNIQUES for BETTER SQUEEZE CEMENTING

"DM-DC" DRILLABLE SQUEEZE PACKERS

Here is another excellent example of Halliburton's integration of tools and techniques. Simple and easy to set, these dependable packers run on drill pipe, tubing, drilling line or electrical well service wire line. When set by tubing or drill pipe, the circulating valve is free from packer before squeezing begins. Back Pressure Valve is closed as packer is set, providing positive fluid shut-off from below. Packer becomes a Bridge Plug when Sealing Plug or Ball is dropped or pumped in place after packer is set.

HALLIBURTON HYDRAULIC WIRE LINE SETTING TOOL

This new method requires *only* rig sand or drilling line to set Halliburton Drillable DM-DC Bridge Plugs and Squeeze Packers or Type "CL" Production Packers. Eliminates the special set-up and footage charge of wire line specialty company. Also saves expensive rig time as compared with setting packer on tubing. The setting tool can be used in wells with or without fluid since the hydraulic setting fluid is contained in the tool. Packer is set by hydraulic force from piston and cylinder arrangement which is actuated by reciprocating the wire line. The line pull required is reduced by the unique design of the piston areas. When sufficient hydraulic force is built up to set the packer, the setting tool frees itself for removal.

HYDRAULIC RETRIEVABLE CEMENTER (HRC)

Designed to perform efficiently under highest pressures and most difficult operating conditions. Simply operated and set easily by hydraulic pressure with automatic testing of tubing as packer sets.

LATEX CEMENT

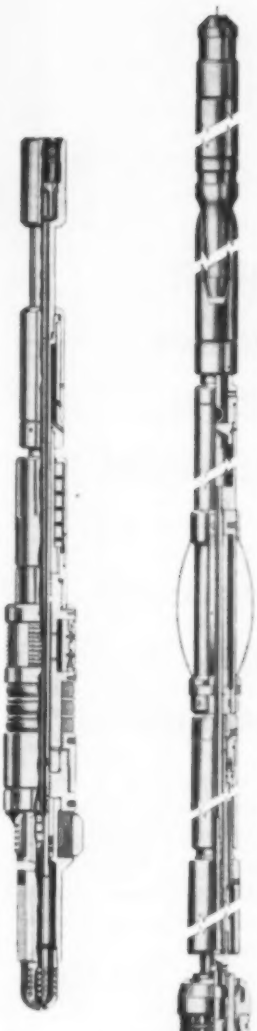
A low fluid loss cement for "tailing-in" on primary cementing jobs, for squeeze cementing or cementing liners. Perforating properties exceptional, with very little shattering; compared to portland cement. Higher resistance to mud contamination, acid, and corrosive fluids with added resiliency and bonding qualities to the cement.

HR-4 CEMENT RETARDER

Used to retard the thickening time of Portland, Pozmix or Latex Cement, allowing placement in wells having higher ranges of temperature. A powder which can be added to bulk cement or to the mixing water with equal success. With Latex Cement, HR-4 improves the filtration properties at higher temperatures.

MCA (Mud Cleanout Agent)

Here is one of the industry's most effective mud dispersant solutions. Used ahead of cement slurry, it has proven helpful in obtaining successful water shut-offs because of its superior cleaning and dispersing properties.



Hydraulic
Retrievable Cementer

Wire Line
Hydraulic Setting Tool
w/ "DC" Bridge Plug

HALLIBURTON

CEMENTING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

284 SERVICE CENTERS—JUST MINUTES AWAY FROM YOUR WELL

BAKER Packers put the "permanent" in permanent-type completions

When you select a Packer for a Permanent-Type Well Completion, remember this fact: of all the tools used in permanent-type well completions, only the PACKER is required to be *permanent*. Guns, Extensions, Plugs, Gas-Lift and Circulating Valves can be removed or replaced on wire line . . . but the Packer, like the casing, is required to perform for the life of the selected producing intervals. Baker Packer Completions are *permanent completions* from the standpoint of packer performance.

Baker Retainer Production Packer Product No. 415-D

Baker Retainer Production Packers have many important advantages . . . Meet dimensional requirements of Permanent-Type Well Completions; provide permanent, reliable pack-off which will hold against any pressure differential (from above or below) that is safe for the casing; Tubing String is free because neither set-down tubing weight nor tubing tension is required to achieve and maintain pack-off, although the tubing may be anchored to the packer if desired; Tubing String readily removed. Packer can be set on a wire line; is readily drillable, and can be used as either a Squeeze or Production Tool.

BAKER OIL TOOLS, INC.

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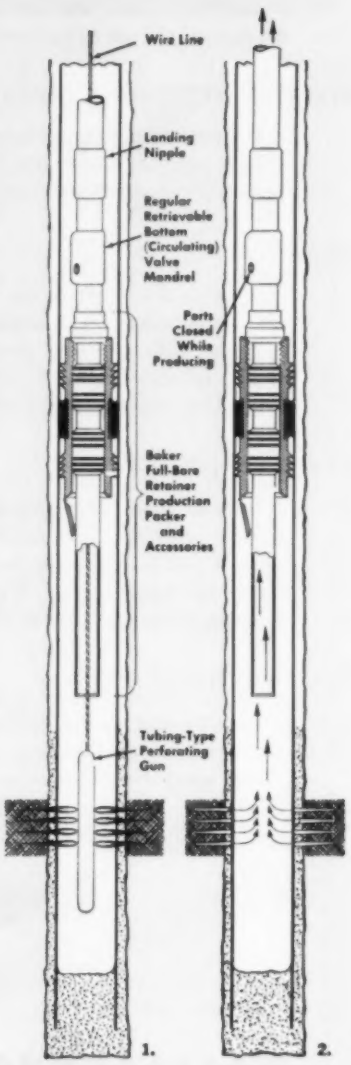


One of the many types of Permanent-Type Completions is shown above. After perforating (1) and retrieving the cable head and collar locater, the well is put on production (2). All subsequent work-overs, such as squeeze cementing to improve gas/oil ratios, are conducted with special tools which are run through the tubing string.

A special survey report on the . . .

DRILLING CONTRACTOR'S VIEWPOINT

. . . on profits . . . losses . . . prices . . . equipment . . . methods . . . and the future of contract drilling

Jack W. Williamson,
Editor

MR. CONTRACTOR, how do you feel about the drilling contracting business today . . . Do you want to get out of this "rat-race" . . . or are you planning to expand your operations? A special study conducted by *The Petroleum Engineer* received a high response and a wide range of answers to questions asked contractors throughout the U. S. and Canada.

Summed up . . . there are too many rigs . . . and contract drilling prices are too low to make a profit . . . These are the conditions forcing many contractors to their knees. What can be done to ease the pressure? What caused rig inventories to get so high . . . and when will a reasonable balance of rig inventory and drilling activity come about? How much do prices need to increase to permit the contractor to earn a fair profit after he finishes the hard work and expense of sinking a hole deep into the earth?

Will you be shocked to learn survey returns indicate average profits this year will be around 0.6 percent of gross income? One West Texas contractor reports that unless price adjustments are made in the near future a great number of contractors will go out of business. Considering the drilling industry's huge capital investment of about $1 billion and the extreme risks and difficult working conditions . . . could anyone say this is a fair profit? To most of the contractors responding, the grass not only looks greener in the fertile land across the fence, but their own back yards look burned up and feel like the great Mohave Desert in the middle of a record-breaking sandstorm!

As one contractor put it "the romance is gone" and the road back to a workable rig inventory and fair prices will take time and be strenuous. The rate of rig decline (taken out of service) appears to be 1½ to 2 times normal—and may continue to accelerate. Even though most contractors today know their cost to drill a well fairly accurately, many continue to turn in bids that will not show a profit and might turn out to result in a loss. This cannot continue, but it has distorted the "fair price" picture in the minds of some producers who may not have had experience in the drilling business or enough contact with it to accurately know true costs. These "low cost" bidders are actually drilling themselves out of business because they cannot replace a major amount of worn out or obsolete equipment when that time comes to them.

Contractors desperately need relief from an oversupply of rigs and too low prices. To get a fair price, capable contractors need to go on the offensive . . . no one can "score" while on the defensive. It is not easy to go on the offensive, but it may save you from certain bankruptcy.

Small vs Large Contractor

When the problems of contractors today are past history, who will have survived? Will there be only a very few small contractors and a preponderance of large contractors, or vice versa. Nearly all the contractors surveyed, expressed an opinion on this question.

One Mid-Continent area contractor reports the drilling industry is at the crossroads on the "size" question now. He says large contractors, some with over 50 rigs, will dominate deep drilling and the small 1 to 5 rig contractor will dominate shallow drilling.

Another contractor from the Rocky Mountain states believes the small contractor who runs top equipment and takes a personal interest in the work will survive. Those who attempt to get business on price alone are already on the way out, as producers are starting to consider equipment and personnel when awarding contracts.

A Canadian contractor believed the large contractor will dominate but there are good opportunities for smaller contractors with specialized equipment such as for slim-hole drilling.

A California contractor says the 3 to 5 rig size will be most successful . . . smaller contractors will lower prices

How this study was conducted. *A cross section list of drilling contractors in the U. S. and in Canada were selected from the time-proven RIG LOCATOR directory. Contractors polled in this survey were selected for their geographical location as well as their size . . . so that an averaging of replies would represent as nearly as possible an expression of the overall industry. Questions were carefully screened as to their meaning as well as what the answers implied. This study is the result of very careful planning as well as careful scrutiny of results and their proper interpretation. We hope it gives a true insight into contractor's situation as it exists today . . . and his outlook for tomorrow.*

—The Editors.

without justification and force themselves into bankruptcy.

A New Mexico contractor states 7 to 10 rigs are ideal, but any future contractor will have to be more efficient and drill with a minimum of fishing and down-time. He must have good equipment, personnel, and know the latest drilling techniques. The producer must be better satisfied with his work.

A Texas Panhandle contractor reports there will always be a place for the small contractor who doesn't owe too much at the supply store and who doesn't "bid like a idiot."

A West Texas contractor says "larger rig ownership is necessary to bring about better economy and business methods."

A Southwest Texas contractor states that "history shows the larger companies are more successful. However, the small contractor who is efficient and specializes in one area will always be successful."

A Louisiana contractor also believes the small contractor can stay in business if his equipment is good and his rate of penetration high.

A large contractor operating all over the U. S. and the world in fact, says there will always be a place for the small contractor who can keep pace with improvements. This demands capital and higher prices for his work. Another sharp Texas contractor says "the ability of the contractor is the most important thing. After all, most of the large companies today were once small . . . good men and time made them large."

From all over the U. S. and Canada came these varied replies. Everyone seems to have a definite opinion on this question . . . what is yours?

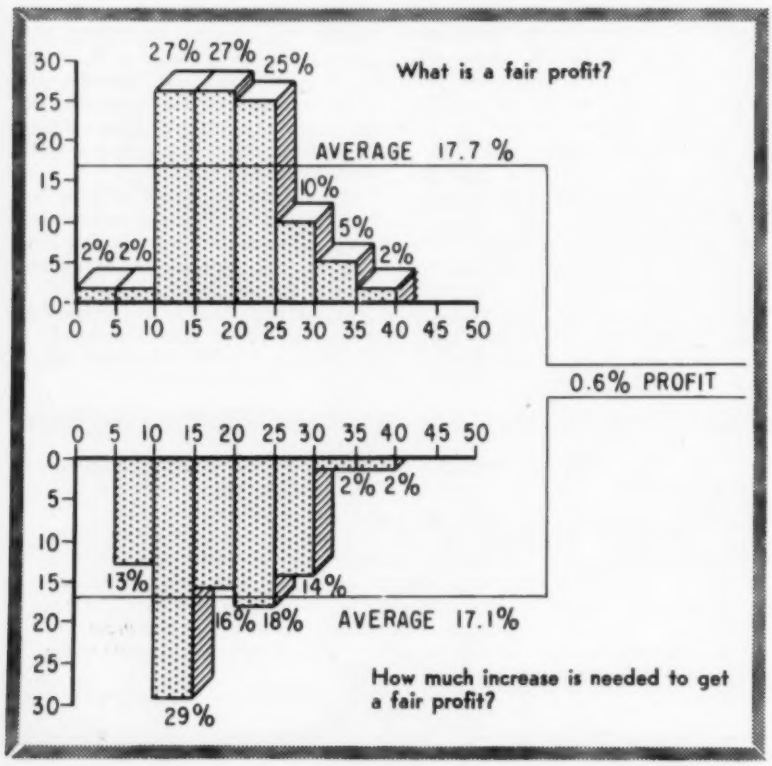
This survey also asked the contractor "what rig improvements were needed most to obtain a faster-penetration rate or to drill at a lesser cost?" Improved pumps headed the list and next was improvements in accessory equipment, such as power tongs, swivels and rotaries. Interest in improving bits and engines also ran high.

New techniques using present equipment offer the maximum benefit at the lowest cost. Survey respondents selected air drilling as offering the best potential in new techniques, although it required the renting or purchase of expensive air equipment. Development of better muds followed as a close second, and a third source was some method of getting more power at the bit.

THE CONTRACTOR'S FINANCIAL PICTURE

FINANCIAL SUMMARY

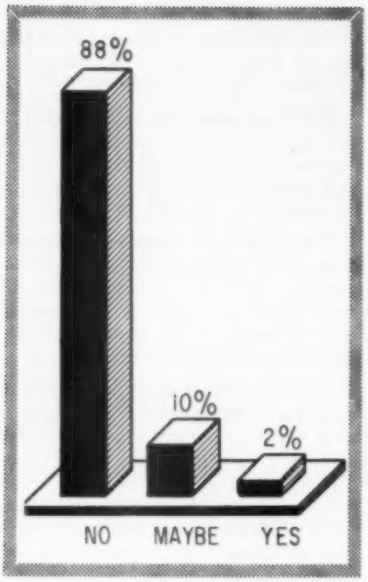
What's a fair gross profit?	17.7%
How much increase needed to get a fair profit?	17.1%
Will contract prices increase in 1958?	88% say no.
How do 1958 earnings compare to 1957?	76% are down.
How much increase in costs, 1958 compared to 1957?	9.8%
What items increased most?	Equipment and Supplies.
Will contractors purchase as much in 1958 as in 1957?	Much less.



Since last summer, the drilling contractor has been in somewhat of an economic "bind." His overhead and other expenses have gone up . . . competition has been bitter . . . and his income has gone down. There are few contractors who have not felt this financial "squeeze." Recognizing that there are inefficiencies in any business . . . both in management and in operations . . . contract drilling has come a long way toward a mature business status since the end of World War II. Today, there are many prudent contractors who have good equipment . . . good men . . . and efficient operation. Still . . . they are in financial difficulty. What's the answer? Judging from the unsigned returned replies . . . low profits appear to be the culprit.

What is a fair profit? 17.7 percent of the gross profit was the average of all replies received. None felt they were making too much . . . a few admitted they were satisfied with their present profit picture . . . and a large majority stated they felt more profit was needed. The highest figure given for this pointed question was 38 percent . . . which is not out of line for many industries that figure as much as 40 percent markup and sometimes more. How do these figures compare with your ideas?

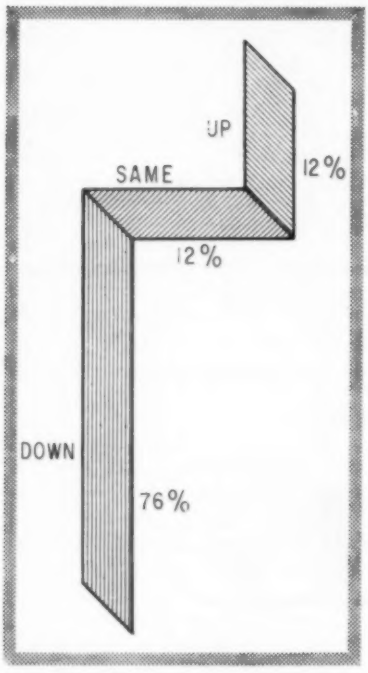
How much should prices be increased for you to realize a reasonable profit? 17.1 percent was the average of replies on this question. A surprising figure when you realize the average contractor wanted a 17.7 percent profit on his gross income. Simple deduction would indicate that the industry is now averaging a meager 0.6 percent. This agrees in general with the feeling of most contractors who stated that pres-



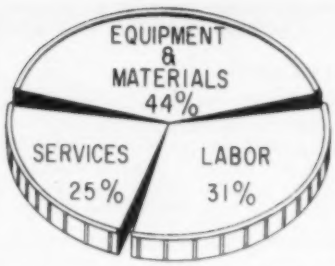
Will contract prices increase this year?

ent operating costs and current contract prices would not permit a fair profit.

This also agrees with statements made earlier this year by C. L. Vickers, treasurer and credit manager for the Continental-Emsco Company (July 1958 issue, page B-46, *The Petroleum Engineer*). His opinion expressed before the May 1958 meeting of the Dallas-Fort Worth Chapter of the AADC, was that if the contractor



How do 1958 earnings compare to 1957?



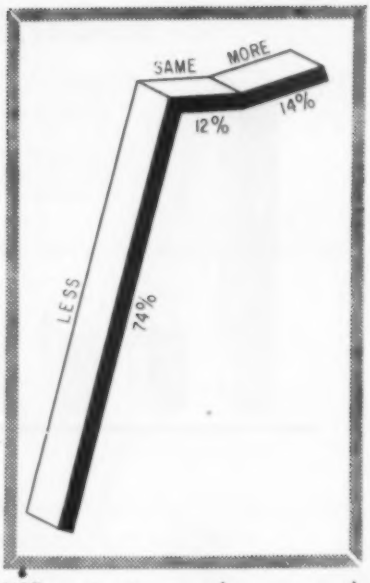
Costs have increased 9.8 percent during 1958 . . . what items increased the most?

continues on the present operating basis, he cannot stay in business.

Will contract drilling prices increase this year? The chances for a general price increase in contract drilling are not good, even though drilling has picked up and is still going at a much stronger rate than this past summer. This was the feeling of 88 percent of the contractors who replied. Apparently the availability of rigs is the prime factor here. For the past year or so there have been many more rigs available for contract drilling than there were wells to drill. How long this will continue is anybody's guess . . . but, apparently this condition will be with us for sometime.

However, 10 percent of the contractors said they felt there was a fair chance that prices could increase. Only 2 percent thought chances were good for an increase . . . how does this compare with your feelings on price increases?

Earnings? What has happened to earnings this year . . . have all contractors lost money? 76 percent report earnings down 37.2 percent; 12 percent earned the same amount; 12 percent increased earnings 32.7 percent.



Will contractors purchase as much drilling equipment in 1958 as in 1957?

How does your company's earnings compare?

Cost Increases. You may be able to get an idea how efficiently your company has been operating by comparing your cost increases this year with the average reported figure of 9.8 percent. 44 percent reported equipment and materials responsible for most of this increase. 31 percent blamed wages and 25 percent, outside services such as trucking, welding, etc.

Purchases. Will your company spend more or less for new equipment in 1958, compared to 1957? 74 percent report they will spend less in 1958; 12 percent the same; 14 percent will spend more.

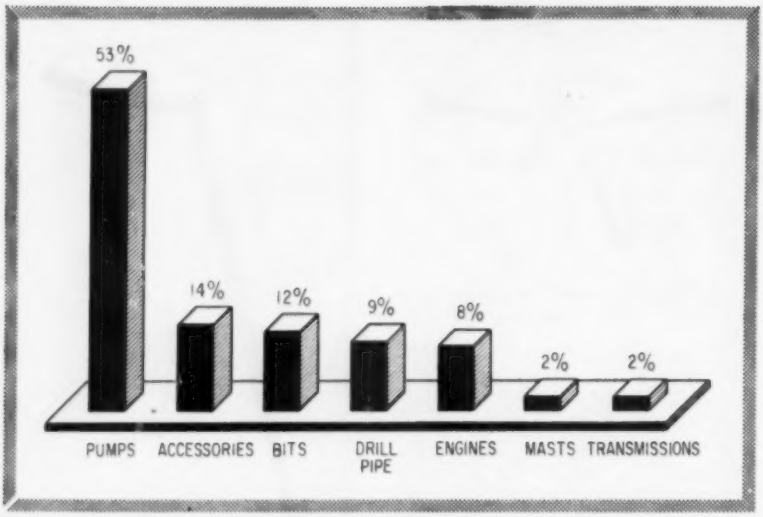
STATUS OF DRILLING EQUIPMENT

How old is your equipment? 60.8 percent of the respondents' equipment is over 5 years old. Using this as a guide, are you keeping pace with the average in keeping your equipment modern and efficient? Only 14 percent of the contractors polled said they would buy more drilling equipment this year than they did last year. 12 percent stated their equipment purchases would remain about the same; while 74 percent would buy less equipment in 1958 than in 1957.

What improvement do you need the most? 53 percent want improvements in pumps. They need to be lighter, smaller in dimensions and pump larger volumes at higher pressures. Yes, this is like getting two tens in change for a five, but major equipment advances will do a lot to help the contractor make a greater profit from present day prices.

EQUIPMENT SUMMARY

How much equipment over 5 years old? 60.8%
Are penetration rates at a maximum using your present equipment? . . . . . 79% say yes.
What major equipment item needs improving the most? . . . . . 53% said pumps.
In designing an entirely new rig what major features would you want most? . . . . . portability and lightness tied for first place.



What major item of equipment needs improving the most?

Deep and ultra-deep drilling, will continue to step up pump requirements. The weight and size of present pumps are a serious burden to contractors operating at all depth ranges.

Improvements in accessories wanted by 14 percent. Power tongs, swivels and rotaries were the choice of some contractors for improvement first. Tongs are the tools used most by the crew and any improvement in them would be important. Down-time for swivel repair when a rig is drilling makes for very expensive repair costs for this item. Even if another swivel is available at the yard it will require considerable time and expense to bring it to the well. While there are many good rotaries on the market, chain drives and torque tube connections presently used to get power to this piece of equipment may not be the best method to drive it. Larger table openings are needed to permit completion equipment to pass through; or if it were lighter, it could be more easily slid or moved out of the way when it is not needed for drilling.

12 Percent want bit improvements. Making a trip is the most time consuming and expensive part of drilling. You are not making hole; the rig and crews are being worked hardest, and another expensive bit will have to go on the accounting sheets. Any improvement in bits that will make them cut faster and stay in the hole longer will be welcomed by everyone in the industry.

9 Percent need better drill pipe. Development of the jet bit and deeper drilling require larger volumes and higher pressures . . . at the bit. It takes a lot of "soup" to get it there now. Contractors want larger ID's, greater strength and wearing qualities. The new alloys to do this job must not be priced out of the range of wide purchase and use.

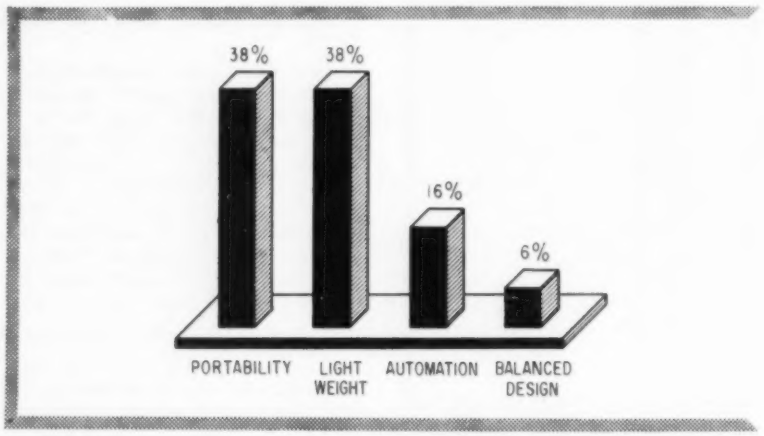
8 Percent can use improved engines. As with pumps, some of the problems are to get more horsepower with less space and weight. The smaller engines of today do not have the lasting qualities of the larger engines. Many contractors are expecting a much more efficient and different type of power to be developed than in use today. Also helpful, would be an adaptable method to use the power source in units, so that power requirements could be changed to meet the extremes of variation in hole sizes and depths. Every contractor is sometimes forced to use his rig to drill deeper than the normal complement of power will permit him to do, very efficiently. He will occasionally have an opportunity to use a particular rig to drill holes more shallow than it will normally operate efficiently; convenient flexibility of power might put this rig in the profitable bidding range for these operating conditions.

2 Percent asked for better masts. Is this a commendation for present mast builders or is this problem so knotty that contractors feel improvements in this field are in the distant future?

2 Percent need improved transmissions. With increased power use, transmissions are also getting larger and more expensive. Again, a reduction in size and weight of this item would help the contractor significantly.

Can penetration rates be increased with present equipment? No say 81 percent, while 19 percent say yes. Equipment and technique both affect penetration rates, but any new technique that will increase penetration rates, using presently owned equipment, will give the contractor the most help for the least cost.

Satisfied with your present rig? When a new rig component is redesigned and placed on the market it must generally be fitted into an already existing rig. This necessarily limits design possibilities. Consider now, if the chief design engineer of a large manufacturer had the rare opportunity to start "from scratch." What major feature would you ask him to develop? 38 percent of the respondents were divided equally between portability and lightness as their first choice. 16 percent chose automation, followed by 6 percent choosing unitization (flexible, balanced components), 2 percent desired better weight distribution. What would be your first choice to help you . . . increase profits . . . get more contracts? Widespread use of new developments cannot be expected to come about until the contractor can . . . buy new equipment . . . and sell its use . . . to the operator at a fair profit.



In designing an entirely new rig, what major features would you want most?

WHAT ABOUT DRILLING METHODS

New techniques are many times developed along with the development of new or improved equipment; or sometimes vice versa. What new, or relatively undeveloped, technique would you suggest as offering the best potential to increase penetration rates? 30 percent believe air drilling offers the best potential; 28 percent feel better muds would help the most. For example, development of muds which would maintain a lower viscosity at all encountered temperatures would help increase penetration rates. 25 percent said more power at the bit . . . at all depth ranges. 17 percent voted for larger mud volumes and higher pressures by means of better pumps and improved design of hydraulic systems.

How much experience in air drilling? 65 percent reported no experience in air or gas drilling, but 74 percent were interested in this relatively new drilling technique.

How popular is slim-hole drilling? Exactly 50 percent reported having drilled wells from top to bottom using 6¼-in. or smaller size bits. Is either the use of air, or slim-hole drilling adaptable in your area?

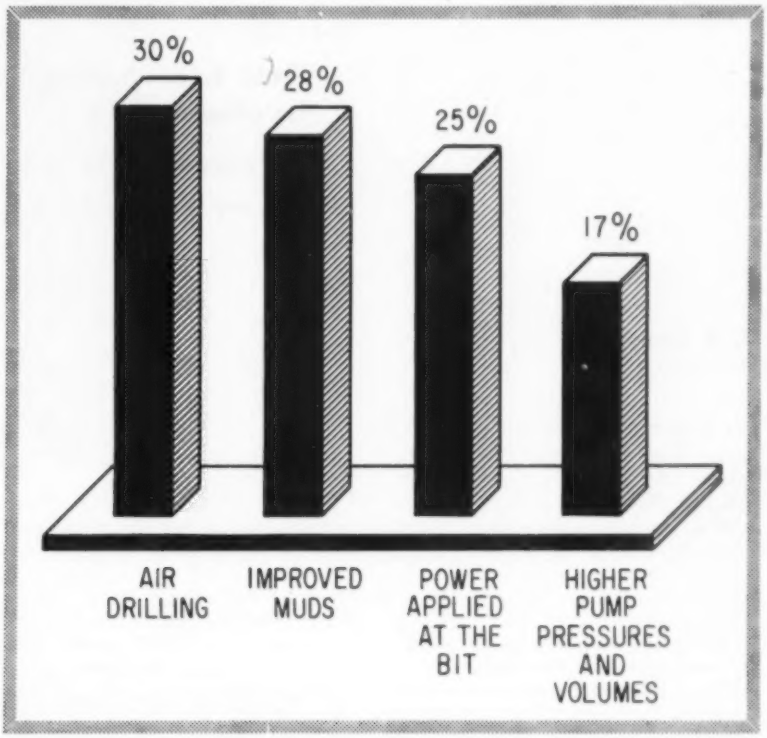
Plan Ahead

Obsolescence. How fast are rigs going out of service operating at today's low prices? 22 percent report they have taken an average of 2.3 rigs out of service this year.If all of these rigs have been taken completely out of service, the obsolescence rate is around 1½ to 2 times the rate in normal years. If a surge of new or improved equipment was placed on the market, and present contract prices continued, the rate of obsolescence would increase significantly.

Interested in foreign operation? Only 14 percent report foreign operations at the present time, but 36 percent are interested in foreign work. Deployment of domestic rigs overseas could materially decrease present excess rig inventories.

NEW DRILLING TECHNIQUES

How many contractors experienced in air or gas drilling?	35%
How many are interested in air drilling?	74%
How many have drilled slim holes and are now prepared for slim-hole drilling?	50%
What presently known technique has the best potential to increase penetration rates?	Air drilling and better muds.



Penetration rates, say 79 percent, cannot be increased using present equipment . . . what idea then offers the best potential for increasing penetration rates?

Future activity. How does your fellow contractor, all over the U. S. and Canada, feel about the immediate future? 60 percent report present levels of activity will continue throughout this year. 38 percent expect rig activity to decline and 2 percent optimistically view an increase.

ACTIVITY AND OUTLOOK SUMMARY

What is the current rate of rig retirement?	1.5 to 2 times normal
How many contractors in foreign work?	14%
How many contractors are interested in foreign work?	36%
Will conditions improve this year?	No — stay about the same.

HOW DOES THE SHOE FIT?

Where does your company stand now . . . in comparison with the reported average? Did any of the foregoing material help you plan for the future? Did you learn any of your company's strong points . . . weak points?

Why not now? Anytime is a good time to start a well-planned company training program. Right now, with the present general low level of drilling activity, may be a good time to carefully examine all phases of your company's operation . . . then start a training program or a rig change needed . . . to get your company in top-notch condition. **Want something for nothing?**

The contractor cannot expect producers to pay for his inefficient operation or to get a price-increase handout. Have you "eyed" your competitor's equipment and do you keep informed on the latest equipment improvements? For example, is your rig as portable as your competitor's? Do you read the literature . . . regularly . . . for the latest in techniques? Do you know the latest advances in air drilling?

If you want to make more profit, you will have to provide better service with good equipment. The wiser operators will pay the better contractors more money . . . because they are getting more for their money than from a cheap contract offered by a cut-throat, inefficient contractor. ★ ★ ★

P 425.42

Progress in...

Water Shutoff in Air/Gas Drilling

Field trials taking "bugs" from promising new treatments

- *Polymeric Water Gel*
- *Low Viscosity Resin*
- *Resin Slurry*
- *Alum-Ammonia*

C. R. Graham
Assistant Editor

TOTAL SHUTOFF of formation water while air and gas drilling is possible . . . but costly. Many areas where water intrusion has nullified air and gas drilling attempts may now be reconsidered in light of recent developments. At least five organizations are actively developing various treatments designed to effect total water shutoff at low cost and with little rig downtime.

Most operators now engaged in air and gas drilling are dividing their water problem into three, according to the amount of water flow. In cases where small amounts of water enter the hole —from weeping formations—operators are learning to live with it by increasing air velocities by adding compressors. Intermediate amounts of water suggests adding a foaming agent to the air stream to facilitate lifting cuttings from the hole. Where large amounts of water are encountered, most operators in the past have converted to a mud program.

It is in the third category that oil companies and service organizations have focused their resources in an effort to make top to bottom air drilling economically feasible.

Four different treatments have been field tested and show promise. Their cost, according to developers, will decrease with increased usage, and effectiveness will increase as placement techniques are worked out and as personnel become better acquainted with the new treatments.

Other companies cite new chemicals now in experimental stages with field tests scheduled in less than 60 days.

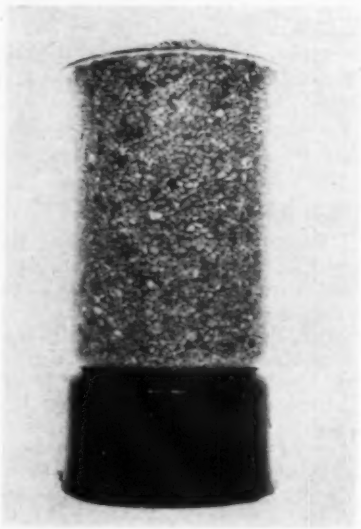


FIG. 1. **Polymeric water gel** forms a stiff, although not hard, set that can withstand relatively high formation pressures. Its stiffness is illustrated as it supports several times its weight of gravel.

STIFF GEL

...Positive Penetration in Tight Formations

Experience in the field application of a polymeric water gel (PWG) is quickly being gained as a water shutoff method in air and gas drilling. This material, being developed by Halliburton Oil Well Cementing Company, has successfully sealed off water zones in air drilled wells in various locations. Several factors point to PWG as a usable tool in this field. (See *The Petroleum Engineer*, June 1958, page B-26.)

PWG, a true solution, is a low viscosity material that will set to form a stiff gel. It has a viscosity of about 3 centipoise which is maintained until it starts to set. This is a definite advantage, since it permits the solution to be easily pumped and penetrating for approximately 95 percent of its fluid life. Once PWG begins to set, however, the reaction is rapid; a maximum stiffness is obtained in a relatively short time after its viscosity starts to rise. Success of the use of the gel depends on downhole temperatures and time factors involved. For this reason, reliable information must first be determined before treatment so that proper solution formulas may be calculated to yield maximum water shutoff results. In many applications, a 2 to 4 hr waiting is necessary for the PWG to set.

Effectiveness of the stiff gels are high. Remarkable plugging properties have been exhibited when the PWG has been placed in permeable matrices. Cores having a permeability as high as 3000 md and only 1-in. long have withstood as much as 2000 psi hydraulic pressure (Fig. 1).

Advantages

Perhaps the most advantageous quality of the PWG is its low viscosity, yielding positive penetration in relatively tight formations. Treatment cost is not now too expensive. Also, formulas have been developed by its developers to cover the range from 40 to 200 F.

Usual PWG setting procedure calls

FIG. 2. **Resin slurry,** as seen in the dark portion, was squeezed into unconsolidated 80 to 100 mesh white sand. Resin leaves the slurry consolidated and plugged the sand. The small broken piece depicts the strong bond that is developed between the sand and resin slurry in that the break did not occur at the interface.

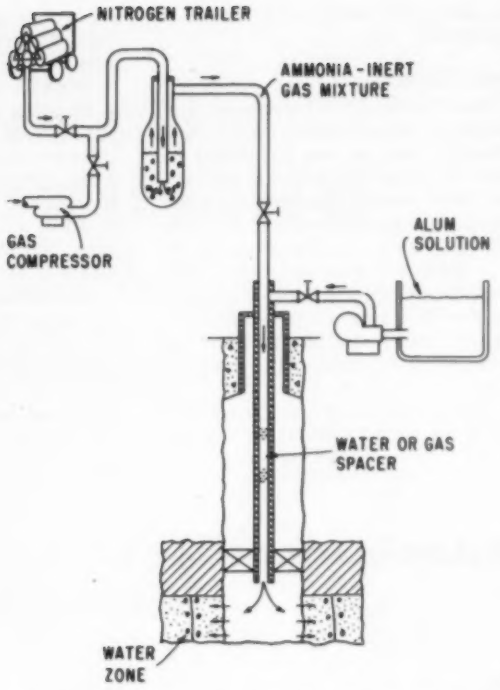


FIG. 3. **Alum-ammonia treatment** is schematically described. The ammonia gas may be injected in either pure or dilute form. Nitrogen acts as a carrier for the ammonia gas and as a spacer between slugs of the alum solution.

for the use of a retrievable packer. PWG can become diluted with as much as 25 percent excess water and still provide a gel of practically the same strength. Because PWG will still give very good results after being moderately diluted, plus the doubtful possibility of sticking a packer in the hole, makes the use of the solution very attractive—in that keeping a hole totally free from water is almost impossible.

Size of the treatments vary, but 10 to 20 gal of PWG per foot of formation treated is presently recommended. For example, one 30 ft zone making 12 bbl of water an hour was totally sealed with 600 gal of PWG.

LOW VISCOSITY RESIN

A relatively low viscosity resin, termed HG-10, has been used successfully to shut off water in air drilled wells. Developed by E. I. duPont, the resin is usually pumped down and squeezed into formation and positioned using drillable packers. The resin weighs 10.8 lb per gal. Basically a thermosetting plastic, the resin reacts quickly and begins setting on contact with water. For this reason treatment must be in a clean hole. Cost is about $9 per gal.

RESIN SLURRY

. . . Applicable in Fractured Formations

The plastic resin PC-11 is now being used very effectively as a slurry when combined with certain inert solids to give a bulking effect and to control the fluid lost from the slurry to the formation. Development of the resin slurry is being directed by Halliburton under the product name, PC-11. Fig. 2 is an example of the set resin slurry when it is squeezed against a water saturated unconsolidated sand. Present solids being used are a fine mesh sand and pozzolan.

In line with characteristics of the resin treatments, the strength of the set resin slurry and the resin saturated formation will vary and will depend on the well temperature, the differential squeeze pressure, and formation characteristics.

For example, the resin slurry, when squeezed into an 80 to 100 mesh sand at a 20 psi pressure differential has given a compressive strength for the slurry and 1050 psi for the sand (after 4 hours at 120 F). Similar data for the 80 F formula have been recorded. Using a 4-hr squeeze at 200 F, however, a compressive strength of 3958 psi was obtained for the slurry and 2509 psi for the consolidated sand.

The slurry normally weighs 16.5 to 17.5 lb per gal. Again, as in the case of the straight resin, a relatively accurate formation temperature is required so that the proper amount of catalyst can be added to the resin. The catalyst-resin ratio is changed so that sufficient pumping time is allowed for the placement of slurry. Water also acts as a catalyst and further accelerates the setting time of the resin—once the slurry is squeezed against the water-bearing formation.

The resin slurry seems to be particularly applicable in fractured formations. Its set is much harder than other similar materials used to shut off water and will control higher formation pressures. Because of the hard set, however, most jobs are squeezed using drillable packers. Its developers point out that it can be used at temperatures ranging from 40 to above 240 F. Considering

the inert solids added, cost per gallon is about $5.

Field Results

Report of one PC-11 treatment, suggesting its effectiveness and a typical treatment size, is one performed by Halliburton in West Texas to seal several water producing formations in the Clearfork dolomite between 7675 and 7780 ft. The Lower Clearfork, in the area of this job, produces water which contaminates drilling fluids and reducing the bit life by corroding the bearings. In this particular treatment, no accurate measurement of the water was made.

The resin, pozzolan and sand were mixed in a mechanical agitation-type mixer in 44 gal batches. Nine times the basic mixture, or 396 gal was used to treat the 105 ft of hole. With a packer in position and using a continuous double plug container, 20 bbl of water was pumped to break circulation and clean formation. This was followed by 7 bbl of diesel fuel from a displacement trailer. The PC-11 was mixed and pumped after releasing the bottom plug. The top plug was released and 10 bbl of diesel fuel run behind.

Considerable field experience is being gained in effective placement of the PC-11 and PWG. Formulas and time allowances are being altered with resulting increased sealing effectiveness, lower cost and shorter placement time and expense.

ALUM–AMMONIA

... Favored in Sand-Type Zones

A liquid and a gas, combined downhole to form a precipitate on the bore hole walls, is being found successful in shutting off formation water encountered while air and gas drilling. The unique method, developed by Gulf Research and Development Company, has proved as high as 99 and 100 percent effective in several different formations of intergranular-type porosity.

The treatment involves a new technique for forming a water-insoluble precipitate within the pores of a rock. Advantage is taken of the difference in mobility of a liquid and a gas in porous media to achieve the greatest volume of precipitate in a given pore. Gulf used aluminum sulfate solution and gaseous ammonia as reactants.

The developers have tested the process in both intergranular and fractured type porosities and report that it has consistently shut off water flowing from formations having sand-type porosities and permeabilities ranging from a few millidarcies to over a darcy.

It was found, however, that the treatment is not particularly suitable for shutting off water from fractured formations although plugging of the order of 50 percent or greater has been achieved in all such applications.

Among advantages of the alum-ammonia treatment are: No reaction waiting time, a low materials cost of about $3 per ft of hole treated, a relatively short placement time, and no unusual requirements for mixing and placement.

Gulf reports that in field use, it is not necessary to measure volumes exactly or control pressures and temperatures with more than normal treating accuracies.

Downhole Reaction

The reaction between the alum solution and the gas is shown in this equation:

$$\underset{\text{Saturated Water Solution}}{Al_2(SO_4)_3 \cdot 18\,H_2O} + \underset{\text{Gas}}{6NH_3} \rightarrow \underset{\text{Solid}}{2Al(OH)_3 \cdot n\,H_2O} + \underset{\text{Solid}}{3(NH_4)_2SO_4 \cdot n\,H_2O}$$

It is seen that a solid precipitate consisting of aluminum hydroxide and ammonium sulfate is formed when ammonia gas reacts to the aluminum sulfate solution. The aluminum hydroxide is insoluble in water and the ammonium sulfate, though soluble, can only be removed from the formation pores by diffusion which is an extremely slow process. The precipitate, although not a particularly firm one, is sufficient to bridge or plug intergranular-type material. Lab tests conducted by Gulf indicated that the material can seal a sand-type zone in which 2-in. thick plugs of the precipitate have resisted extrusion by fluid pressures up to 1500 psi.

Field Procedure

In most cases, the treatment was made after the amount of water entering the hole from the formation was determined. Then either single or straddle packers were set to isolate the zone from the rest of the hole. In some cases where the drilling information was not clear, the location of the water producing interval and its extent were determined with an electric log. After setting the packer, the treatment was begun by injecting about 10 gal of a saturated alum solution for each foot of hole to be treated, and then following it with a slug of inert gas. In this case nitrogen was used. Then about 20 std cu ft of ammonia gas, either diluted or in pure form, was injected for each foot hole being treated, and then followed with another slug of nitrogen. Fig. 3 is schematic of generalized field procedure.

After the pipe and the hole opposite the water zone had been filled with nitrogen, more aluminum sulfate solution would then be injected and followed with inert gas until the formation refused to take more fluid.

The developers have recorded significant results in several wells. In an Oklahoma well, a treatment was made in three zones making approximately 30, 11, and 53 bbl per hr. Although the first zone was inadvertently fractured, a partial seal was achieved. The middle and third zone were successfully treated: The 11 bbl per hr zone was totally sealed and the 53 bbl per hr zone was reduced to ⅓ bbl per hr.

A 300-ft weeping zone in an Arkansas air drilled well had stifled any progress until Gulf applied the alum-ammonia treatment. The zone occurred below surface casing at 621 ft with the entire 300 ft-section wet. Starting at the bottom of the hole and using a straddle packer with a 48-ft spacing between hydraulically-operated packing elements, each 48-ft interval was tested for permeability by attempting to inject water into it. If permeability was indicated, the packers were unset, the excess water blown out and the zone tested. If the zone did not take sufficient water, the packers were moved up the hole and the next interval was tested. Proceeding in this manner, three permeable intervals were given the aluminum sulfate-ammonia treatment. After removing the packers, the drill pipe was run to bottom, the hole was successfully blown dry, and drilling proceeded to 3300 ft. A 100 percent water shutoff was effected.

Accidental fracturing of several sensitive formations occurred during the gas injection phase of some earlier treatments. However, it was determined that treatments should stay below a commonly accepted critical value of 0.7 psi per ft of depth. Bottomhole pressures, in most field applications, are now being a point not exceeding 0.6 psi per ft.

(Continued on Page B-32)

Progress noted in . . .

THE FIVE M'S IN CONTRACT DRILLING

As a contractor, where do you stand in the five M's of business: 1. Men; 2. Money; 3. Machinery; 4. Merchandise; and 5. Markets?

An editorial staff study

IN SPITE of the present surplus of drilling rigs, contract drilling is certainly not a common-place business. It falls in the category of specialized service when compared to a list of normal business operations. That is what makes it interesting and, under proper conditions, rewarding as a career; and financially as well.

It does have in common with other business, however, the basic tools with which any commercial enterprise is sustained. These tools are the five M's summed up above. Management's skill in coordinating and using these tools will decide if your company stays in good operating condition today; and whether it will grow in the years ahead.

1. MEN . . . your most important asset

While it may not be as difficult to find good men today as it is to find sufficient money, no one can deny that "good men" are the most important assets of any organization. Men engaged in drilling . . . from the weevil roughneck to the contractor-owner . . . are now and have always been a special breed. The drilling industry has been termed the last stand of the rugged individualist.

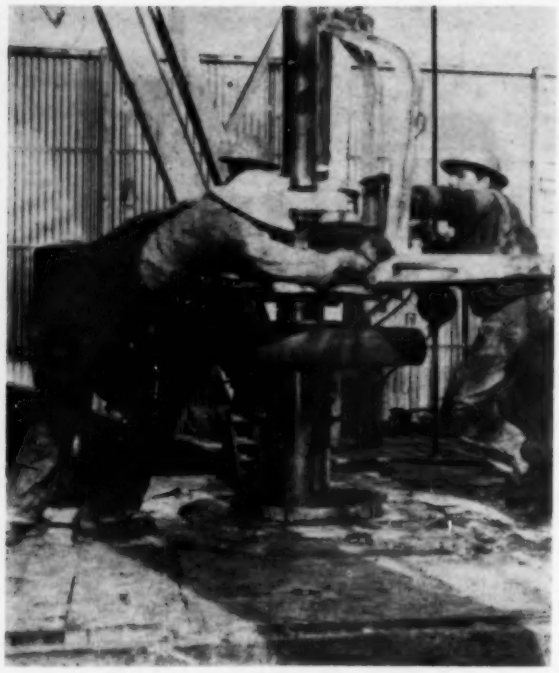
The men who are on top today are those who have "bare knuckled" their way up from roughnecking to drilling to tool pushing or to working as contact man. New drilling companies were often formed when a seasoned toolpusher or drilling superintendent convinced a supply company or investor that he could be successful on his own. The usual pattern was for this progressive individual to keep buying rigs until either poor operations or general drilling activity caused him to be forced into bankruptcy, or to sell out in order to pay his debts. There is a great deal of romance in the drilling industry, so most of these hearty individuals regained confidence and started back up the trail wiser men.

In the old days a contractor hired his men by sending the toolpusher into pool halls with orders to hire three drillers and tell them to get their crews together, and be on location in the morning. Often, the contractor did not know any of the operating personnel until after surface pipe was set. By the time a man could qualify for the title of toolpusher he could pack his own weight when the going was rough and whip any two men on his crew. These men had very little education for the most part, but no other industry can claim their men had such guts, rugged initiative, inventiveness and loyalty to their jobs.

Training of Men

In the mid-1930's there were very few men in the industry who had obtained a college degree of any kind. In fact, most of the industry cast a raised eyebrow at the man with a "sheepskin." However, the college graduate eventually established himself in contract drilling and in drilling departments of operating companies. Over a period of time, they convinced most contractors how ridiculous was their personnel program. It was very convincing to point out that no other industry would invest a quarter of a million dollars for a highly engineered piece of equipment, and then turn the entire operation over to those who had not even completed grammar school.

The increased activity during World War II brought home this point. The first organized training programs for drilling personnel were organized by progressive drilling contractors from West Texas and other interested people in the extension division of The University of Texas. The first successful training program dealt with the subject of drilling fluids and the success of this program is now well known. Since the first group some 8500 men have received this specialized training. Soon after this program began, the AAODC organized the Education and Training Committee which underwrote the cost of this program, as well as sponsoring training programs in additional phases of the industry. Some of these programs have involved supervisory training, safety education, care in handling of drill pipe, drill collars,



Trained, loyal crews can give your company a good reputation and higher net profits.

casing, lubrication, and the handling of wire line. Many companies now have their own training programs to satisfy their own needs.

As a result of these training programs there is much greater team work from the drilling personnel, and they are much more versatile in changing from one position to another on short notice. Of course, they are able to do any job more efficiently and to have more respect for each function they perform. Many crews are now rigging down and rigging up completely themselves, and are able to overhaul their own engines without the supervision of a factory service representative. Similarly, they are able to overhaul and maintain other rig components such as the drawworks compound, swivels, rotary tables and mud pumps.

One contractor who is using a progressive training program has lost only four men since this program was inaugurated. Naturally, this company is enthusiastic about its results, and the company has saved a significant amount of money by enjoying lower compensation insurance rates.

Training programs are relatively expensive, but progressive companies in every industrial field have found them well worth the cost. It was in the middle of World War II that one of the DuPont family was asked how its organization was able to expand, and take on so many large-scale projects. His answer was "trained men." The DuPont organization, he stated, was half way through the depression of the 1930's before it realized every $100 spent in training of men, earned as much money as $100,000 spent on machinery and equipment.

Every company should check continually its operations to see that its personnel does not lack training that might prevent costly mistakes. It is sometimes difficult to trace where a faulty operation began; and all of the faults leading to an accident or mistake, are seldom found at the time or place of occurrence. Good training programs . . . and continuous training programs . . . will keep to a minimum operation by the trial and error method.

Most drilling companies recognize, for example, that the driller is the key man on any crew. His handling of personnel, expensive equipment under his control and his ability to communicate with his superiors in the company, both in writing and orally, make him an important controlling factor in the company's profit and loss statement.

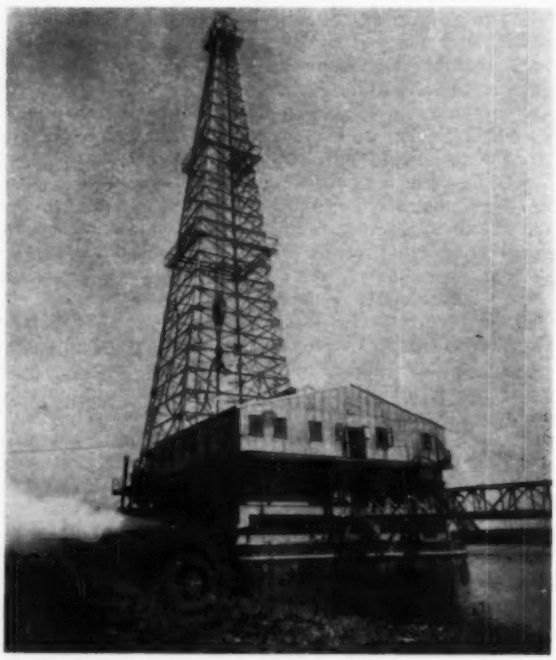
Training is important, but it is also important that a wage scale be maintained high enough to attract the quality of manpower needed. At one time, the drilling industry was known for its high rate of pay. However, in the past few years the wage scale in contract drilling has remained somewhat stationary while many other industries have increased wages as well as important fringe benefits.

When the drilling industry again receives a fair price for its work, this problem will be overcome, as drilling contractors have always been generous in rewarding employees when business conditions have permitted. In the meantime some contractors are operating on a bare minimum, or loss, to hold its key people and to expand rapidly with competent personnel when drilling activity again increases.

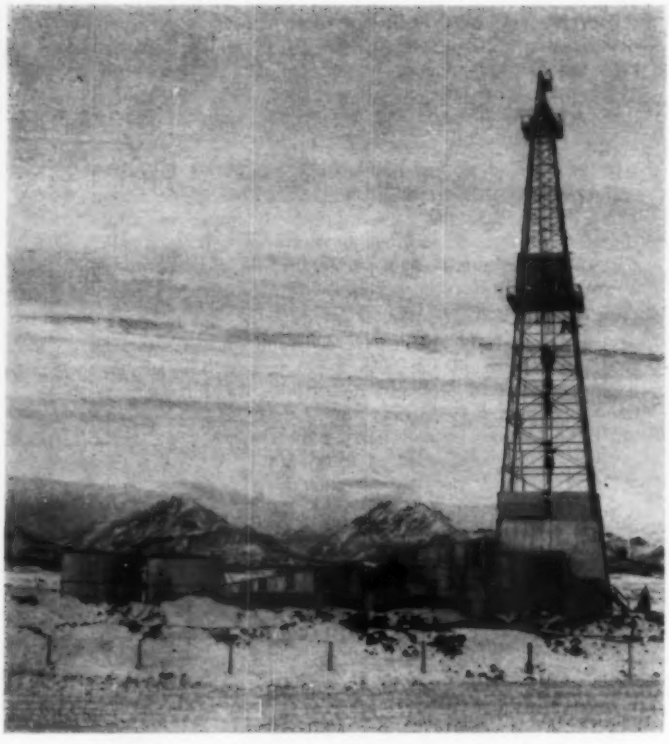
2. MONEY . . . the almighty must in any business

Good accounting important. Let's take a look at that all important tool of any business . . . money. The fact that money is a tool with which to work, and not just stuff with which you buy something, was realized by most contractors in the late 1940's. It was then that the American Association of Oilwell Drilling Contractors published a small paperbound volume, "A Manual of Accounting for the Oil Well Drilling Contractor."

Proof that a large number of contractors have used good accounting principles in the management of their money is shown by the revision of the accounting manual in 1952, when the second edition was published. Again, in 1957, this book was completely revised by the Accounting Committee of the association, and now is considered to be an "accountant's manual" for the industry. Further, over 4000 of these books have been sold. This is very impressive when you realize that there are only slightly over 1000 drilling firms in the industry.



Towering 225 ft above the swampland . . . this massive assemblage of equipment is expensive to own and operate.



Operation in cold climates challenge men and equipment.

The greatest interest and emphasis on accounting has been in the past five or six years, when many firms have employed full-time and highly competent accountants. These accountants have been employed not only to take care of tax matters, but for their ability to handle money owed, money on hand, and to collect bills quickly from accounts receivable.

The accountant has become another important advisor to the contractor, and has helped to make his operations more efficient and profitable in many ways. For example, the accountant has been able to point out the difficulties created by the once time-honored practice of so-called "hip-pocket" bidding. Instead of figuring a bid on an envelope grabbed out of his hip pocket, most contractors will now consult carefully with their accountants and engineering group (if they have one) before submitting a bid on any well. By having all the knowledge that a good accounting system can provide, the contractor is in a much better position to make an intelligent bid. The accountant's report is now as important to the contractor as his daily drilling report.

Since February 1957, when the Suez crisis ended, most phases of the oil industry have been ailing. Large stocks of domestic crude and refined products were built up. Of course, the entire domestic demand for petroleum products levelled off, causing even greater build-up of domestic stocks. With the law of supply and demand working again, money began to be in short supply.

Two other important factors have increased crude oil and refined product stocks. Ironically, the rapid and tremendous development of gas production in recent years has measurably decreased the demand for crude oil. It is estimated that the heating value of 6000 cu ft of natural gas is equivalent to the amount of fuel oil produced by one bbl of average crude. This cleaner fuel, at a competitive price, has received wide acceptance in the Eastern industrial market . . . and its co-product, natural gasoline, has also affected the demand for crude oil. At present, approximately 500,000 bbl of natural gasoline is produced each day.

In this case, you don't need your accountant to tell you why crude production has been so severely curtailed in the past months and why it had to be continued so long before domestic stocks were significantly reduced. This also explains why the independent producer, who normally drills 79 percent of the wells, has reduced his drilling program so severely. With greatly reduced revenue and with only short-term money available at high interest rates, it is difficult to see how the independent could have survived without the life-saving 27.5 percent depletion tax allowance.

Under these circumstances, it is a surprise and a great tribute to the money-managing ability of the majority of contractors that surprisingly few have gone out of business since February 1957, by way of the bankruptcy route. Most contractors quitting business have sold their rigs and settled their accounts honorably. A good many have assigned rigs back to his creditors, and others have merged in order to survive. The increase in foreign activity has been a boon to some contractors, while others have stacked rigs and are waiting for a higher level of drilling activity.

It is interesting to observe that a number of contractors still enjoy a good business, even though net profits are now decreased, percentagewise. A few contractors in this group are busy because of unusual drilling obligations of their customers. However, a majority of this group have maintained a high level of activity because of superior equipment and services, now and in past operations. These contractors are doing a good job of managing the five M's of contract drilling. This enviable position cannot be readily achieved by quickly modernizing rig equipment or employing additional personnel.

In summary, the majority of drilling contractors in business today have developed a sense of business acumen that was not believed possible for them to develop 10 years ago. Their inate sense of integrity has verified the faith of their creditors, even in this day of fierce competition and meager returns on their investment.

3. MACHINERY . . . a continuous flow of improvements

The basic components of the average rotary drilling rig have changed very little over the past 15 years. The steam rig has almost disappeared because of its high fuel consumption, although it was a good hole-maker. Development of new techniques for existing equipment has out-distanced the development of new equipment, and this has permitted many contractors to stay competitive in the drilling business using old equipment. Both new techniques and new equipment have worked together to increase penetration rates.

In 1943, the drill collar was a dubious evil carried between the bit and the drill pipe for extra weight on the bit. Generally, four collars were the maximum in hard rock country, and often none were used in the Gulf Coast. Research sponsored by the AAODC at Battelle Institute demonstrated that drill pipe failure due to corrosion fatigue could largely be eliminated by running the drill pipe under tension. Other advantages were increased penetration rates and greater ease in maintaining a straighter hole.

The additional number of drill collars used, sometimes as many as 20 or more, created problems and made it necessary to redesign the pins and boxes to carry this additional weight load. The solution of this problem took time, and the use of additional collars was not widely accepted until 1948. By 1952, most rigs were using enough drill collars to keep the drill string in tension and do a good job of drilling. Bits were examined in much greater detail about this same time, to see if they could be made to cut faster. Studies revealed that

The drilling industry will go to any place in the world to drill for oil.

a large part of the cutting edge of the bit was being used up regrinding cuttings that already had been cut from the formation but had not been transported clear of the next set of cutters. Bit water courses were redesigned, so the drilling fluid would impinge forcefully on the formation right behind the cutting teeth. This swept away loose cuttings, enabling the next cutter to contact virgin formation.

This was the beginning of the jet bit which created hydraulic problems. Attention was focused on the slush pump. While improvements have been made, intense research continues on pumps. Development of low water loss drilling fluids has also helped solve the problem of more hydraulic horsepower for the jet bit.

Maximum pump input ratings 10 years ago were on the order of 600 hp. Today, there are a number of pumps in operation rated over 2000 input horsepower, and pump manufacturers report even larger pumps on the drafting board. When more hydraulic horsepower is required, pumps are compounded in either parallel or in series to produce high pressures and high volumes.

Dimensions and weight of high horsepower pumps have burdened the contractor with increased capital expenditure and moving costs. This problem will continue to be knotty, but progress will be made.

A recent development has been the use of aluminum and a radical new design for a pump in the 1500-hp class. Its weight is about 60 percent less than a conventional duplex power pump of equivalent rating.

Development of the jack-knife mast which features greater portability, ease of erection and lower maintenance costs, has been an outstanding change in rig design. These advantages greatly outweigh any disadvantages this type derrick may have over the standard API derrick, but it is interesting to note the pattern of acceptance of this new type derrick by contractors. With all these advantages, one manufacturer reports that as late as 1948, two-thirds of the rigs in operation were still equipped with the standard derrick. The change-over from that time, however, was quite rapid.

Development of present-day substructures is comparatively recent and resulted primarily from the demand for more safety in rig operations, ease of moving and setting up. Substructures are now being examined to determine if they can be lightened and designs changed for greater functional use.

Improvement in the design and quality of accessory equipment has been very important to the drilling contractor. Almost every item has been significantly improved within the past 10 years. Slips, tongs, blowout preventers, air compressors, water pumps, light plants, feed-off devices, are but a few items that have been greatly improved.

In the field of really new creative design, the drilling industry has carefully watched the development of the turbine drill. As is generally the case, the advent of basically new equipment creates problems and strains on other components. In this case, bearing failures of bits have occurred due to higher rotation speeds. However, the principle of the turbine drill is being received as sound and time will see the solution of other problems connected with its use.

Power swivel . . . developed further. Additional investigation into the possibility of eliminating the rotary table has initiated the design and testing of a power swivel. This tool is in an early stage of development, but it appears to offer advantages over the conventional rotary table used. Present tests indicate that at 9500 ft, 50 hp are adequate to rotate the drilling assembly in normal operation, with peak loads requiring less than 100 hp. As with many new interesting developments in tools, the cost is high.

Use of electricity for rig power, utilizing new developments in this field, has aroused much interest. Operation characteristics of the electric powered rig is in many respects similar to the once-popular steam rig. Ease of control, smoothness and greatly decreased noise in the area of the rig floor, are among the important advantages of electric power.

To date, all electric rigs have utilized direct current with a few exceptions. Presently operating offshore is an electric rig utilizing alternating current. The power equipment was salvaged from U.S. Navy surplus stock, and the motors driving the pumps and drawworks are 440-v, 3-phase, synchronous. Use of this equipment has been made possible by the development of the dynamic magnetic clutch and magnetic fluid particle brake. This new clutch allows slippage without loss of power and is easily controlled by a rheostat from 100 percent slippage to 0 slippage. Thus, it is possible to balance out the power demand of any unit in respect to any other unit in common operation with this power source. Manifold problems exist in the manufacture and supply of this type of equipment to the contractor.

One of the most important developments in recent years has been the advent of air or gas drilling. Penetration rates have been increased from 100 to 500 percent, and savings have been of like order. Much has been written on air drilling, and everyone has followed it with close interest. When the serious disadvantage of excessive water flow has been controlled, the areas where this method may be used will be greatly increased.

As improved techniques for increasing drilling rates are developed, it has been noted that closer tolerances are required both of equipment design and operation. For example, in drilling with air, the annular velocity must be held above a required minimum or serious trouble will develop quickly. In comparison, when mud is used and the circulation rate is decreased, operations may continue, in most areas, without serious trouble except for decreased penetration rates.

There are many improvements to be made and problems to be solved in the use of air for drilling, but it has progressed

far enough to know that it is here to stay. This method of drilling will offer tremendous improvements in penetration rates when it has achieved a higher stage of perfection.

Slim-hole drilling has been around for many years, and its development has been extremely slow. Slim-hole drilling is generally defined as drilling a hole no larger than would permit the setting of 5-in. casing for the oil string. In very detailed studies of why past slim-hole operation has not affected the savings anticipated, a new and important thought is gradually emerging.

This idea came to light when it was found that early attempts at slim-hole drilling with large rigs did not result in a savings, but actually in many cases increased the cost of slim holes over that of conventional size holes. It is now generally agreed that it is false economy to attempt slim-hole drilling with conventional hole-size equipment.

With properly designed slim-hole equipment, an average 30 percent savings can be realized over the cost of drilling a conventional size hole. This would seem to be enough savings to attract greater development in this field, and contractors are now looking very closely at combinations of equipment being used to drill any hole size, large or small. It may be impossible to have a rig for every hole size, but it is important to know that significant savings can be made when equipment of proper design is placed on the job.

One major company, in 1957, reports drilling 457 slim-holes which resulted in savings of $2.9 million over the estimated cost of drilling conventional size holes. This company believes that even greater savings will be possible in the future because of this experience in drilling slim holes. As a result of this program it was determined that a 6¼-in. hole size and 4½-in. casing were the most economical and satisfactory for its particular operations.

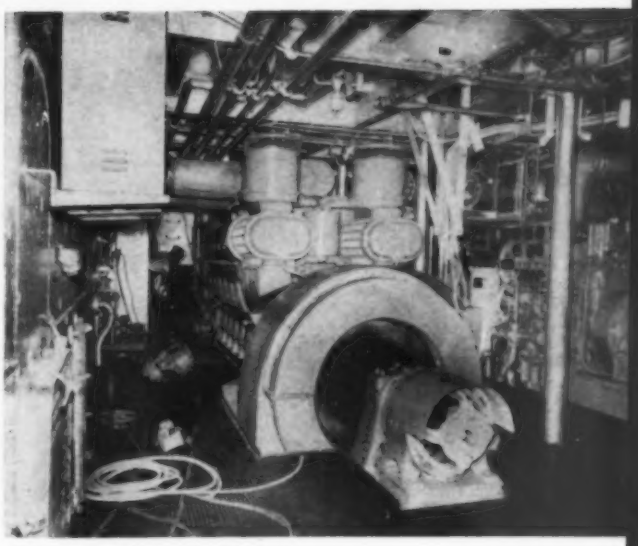
Dual completions have been made without difficulty in 4½-in. casing and no difficulties were encountered in holes as deep as 7500 ft. Roughly, they were able to drill 12 slim-hole wells to a depth of 7500 ft for the price of 9 wells using conventional size holes.

Rig Standardization

This is one of the most important and controversial subjects in drilling today. Is it good or bad, in the long run? This question will be answered in due time and it will be important for you, as a rig owner, to have the right answer as soon as possible. In its purest form, rig standardization involves buying a complete rig, including all components, from the same company. Minimum standardization requires that you buy, for example, the same brand and size swivel for all your rigs having the same depth rating. Every contractor feels that his "authorship" in the assembly of a rig is important, and he naturally takes great pride in this so-called "authorship."

Perhaps a good way to examine your own company's equipment is to appraise, in retrospect, how well some of the equipment combinations you have used in the past have worked out. In actual practice, have all of your selections resulted in the savings or desired operation that you had planned? Again, ask yourself the question, have you encountered difficulties, extra expense or time delay, that could have been prevented by a rig standardization program? Could your maintenance costs have been less, and your investment in necessary parts stock been decreased? Wouldn't it be helpful now if you could cannibalize any part of your idle equipment, rather than having to buy new replacement equipment to be used on your active rigs?

When you have answered these questions, perhaps you can answer the question of how much better in performance does another brand of equipment have to be before you can afford to break a standardization practice.



Main power plant of an offshore rig.

Rig standardization also needs to be considered in the light of additional savings that could be made in the further development of this practice. If the rig manufacturers had complete purchase loyalty from a larger number of contractors, they could devote more time and attention to the coordination of rig components, and change designs to reflect greater savings that are possible by complete rig standardization. When the equipment engineers do not know precisely what components are going to be used in any one rig operation, the design of any component is limited to a considerably degree. Some manufacturers have estimated that 25 to 40 percent of equipment costs for a total rig could be saved if complete standardization could be utilized. Equipment standardization has been important in many other industries and the drilling industry must study the features of standardization . . . and determine its true merits for the drilling contractor.

4. MERCHANDISE . . . service is a contractor's prime product

This brings us to our fourth "M" . . . merchandise. Inasmuch as the drilling contractor's product is a hole in the ground, the salvage value of this product is very small. Unless the dry hole can be used for a water supply or disposal well, additional money must be spent to plug and abandon it. It would appear then . . . service is one of the most important products the drilling contractor has to sell. To supply this service, the contractor must demonstrate that he not only is financially solvent, but has the equipment, supervisors and qualified crews to do a good job.

A drilled hole must be straight within close limits and not have severe dog-legs. It must be drilled as close to the bit gage as possible, and the greatest economy exercised in the use of drilling fluid. A hole must be maintained in such a manner that it can be readily tested and logged, and all of these operations must be carried out with respect to a rigid safety program. Unlike many industries, the contractor must move and set up his hole manufacturing plant to a new location for each new well.

The drilling contractor can be proud of his service to the gas and oil industry . . . he is providing this specialized service at an all-time low cost. Today's unit price, or cost per

Pumps get larger and heavier as pressure and volume demands increase.

foot of hole drilled is less than it was in 1941, when the average was $4.90 per ft. This record low has now been replaced by today's average cost of $4.65 per ft, and this does not reflect any correction for the tremendous rise of inflation over this 17-year period!

Compared to costs in 1941, present equipment prices are 240 percent higher; labor costs 200 percent higher; taxes, insurance and other items of expense have increased similarly.

Although the drilling contractor has done very little to sell his services more effectively, he has for some years now employed a contact man when it was not possible for him to spend sufficient time on this necessary activity. On the whole, contact men have done an excellent job for the contractor and will continue to have an important function where the size of the company will justify his support.

It is thought by many that the drilling contractor has not been a good merchandiser of his services. Almost every other industry has found this to be an important phase of their operations; there appears no reason why this phase should not merit additional attention by the drilling contractor. What has been done has been very good and the contractor has gained in stature with his customers as a result of these efforts.

5. MARKETS . . . the outlook for drilling

Much thought is being given to the last "M" of the drilling industry . . . markets. We have seen that contract drilling prices are at an all-time low, and it is well known the industry is operating at approximately two-thirds its 1957 capacity. Most expert economists predict the demand for petroleum will not increase significantly until 1960, however, no one has suggested how the drilling contractor can stay in business at today's prices until that time. One sizeable contractor recently stated that his company's capital investment in rigs amounted to $1½ million, which required maintaining a working capital balance of about $600,000. This past year, the company's net profit was less than 2¾ percent interest paid on government bonds.

However, the drilling industry is a seasoned time-and-tried industry; so are most of its members. While the water is deep, the contractors who have guided their companies wisely in the past, can do so now. These companies will be here to enjoy the future benefits of this industry and after all, isn't this the American way of life? ★ ★ ★

(Continued from Page B-26)

PROBLEMS

. . . Placement, Packers, Personnel

Operators of air and gas drilling equipment are for the most part trying to adapt their operations in line with latest water shutoff methods. In many cases, however, cost of the treatments exceeds both time and cost limitations, and in some instances they have noted minor formation damage in efforts to continue air or gas drilling. This has been caused, they say, because of initial treatment costs. Placement time and setting time of a water shutoff treatment often offsets previous gains made by fast air drilling. Operators further contend that in and out of the hole trips to effect a treatment is too costly in time and money. For these reasons, companies are studying new methods and techniques and are attempting to acclimatize personnel to "gentle" squeeze treatments necessary to avoid fracturing the water formation.

Several new pieces of equipment and products are in the experimental stage to remove the remaining barriers from effective, economical top to bottom air drilling.

Dowell Division of Dow Chemical is testing an emulsifier to attack the water shutoff problem in a different manner. In other water problem work, Dowell is to test within 60 days an agent that will make cuttings water repellant.

In an effort to eliminate expensive trip time associated with water shutoff treatments, Halliburton has announced that it is developing a drill collar squeeze-packer which can be run in the drilling string above the bit and will make possible the squeezing off of water-bearing formations without coming out of the hole. This report was made public in a meeting of the Joint Air and Gas Drilling Committee of the Southwestern District API-AAODC.

At the same meeting, Lane-Wells indicated that it was perfecting an electric tool which can be run into open hole to locate water-bearing zones. Such a tool would erase the treatment placement problem.

The Untested

Most major oil companies readily admit that each have several "potential" water shutoff chemicals on their laboratory shelves. In some cases, these remain untried because of the cost of the treatment itself; others contend that present air and gas drilling activity has not warranted expensive tests. Some are relying on chemicals now being used to permit drillers to "live with" larger amounts of water and continue drilling. These include foaming agents, water absorbing agents and water repelling chemicals.

Nevertheless, wider use and increased experience with treatments and tools at hand is certain to yield more effective treatments—and at lower cost. The water shutoff methods described here should certainly set the pace. ★

Highly portable rig can be moved completely in eight loads. Pumps, drawworks, derrick, pipe baskets and dog house are all trailer mounted. In 113 wells, average time to tear down, move, rig up and set surface casing is only 33.7 hours. Moves averaged 38 miles.

Slim holes in the Denver-Julesburg Basin...

Save $5000 Per Completed Well

Quick moves, with highly portable rig, fast drilling, 4½-in. casing in 6¼-in. holes provide an economic advantage in the Nebraska and Colorado regions

C. M. "Pat" Ashby, Jr.,
Ashby Drilling Company, Dallas, Texas

FIG. 1. Rig tracks of Ashby Drilling Company's Rig No. 1 across seven counties in the Nebraska-Colorado portions of the Denver-Julesburg Basin.

DURING THESE PRESENT TIMES of belt-tightening, the oil industry has made real strides in reducing the cost of drilling for and producing oil. This is a remarkable feat in itself when a majority of the steel and equipment manufacturers have raised prices when operating at 50 percent of capacity.

In the Denver-Julesburg Basin, good stiff competition has reduced footage drilling costs to operators by 25 percent since 1956, while the contractor's costs have gone up an estimated 16 percent. This reduction has been possible by operators programming their drilling and by contractors increasing their footage drilled per day.

A further reduction of $5000 per 6000-ft completed well can be accomplished by using reduced hole and casing sizes, i.e., "slim-holes." The following savings can be brought about in 6¼-in. hole vs 7⅞-in. hole on those items and services normally paid by the operator.

"Typical 6000-Ft Well"

1.	Less location cost, rig requires less area and mud system is smaller, therefore reducing backfilling costs ..... Estimated	$ 200.00
2.	7-in. surface vs 8⅝-in. (300 ft)	274.20
3.	Surface pipe cement. 75 sacks vs 150 sacks. 75 sacks at $2.10	157.50
4.	Mud cost. $640 vs $800. Less volume required ...	160.00
5.	Lower contract footage price. 6000 ft at 20¢/ft. ..	1,200.00
	Total savings on dry hole	$1,991.70
6.	Oil string savings. 5000 ft 4½-in., J-55, 9.5-lb and 1000 ft 4½-in., J-55, 11.6-lb vs 6000 ft 5½-in., J-55, 14-lb	3,007.60
7.	Trucking oil string savings	162.00
8	Cement oil string savings	96.00
	Total Savings on Completed Well	**$5,257.30**

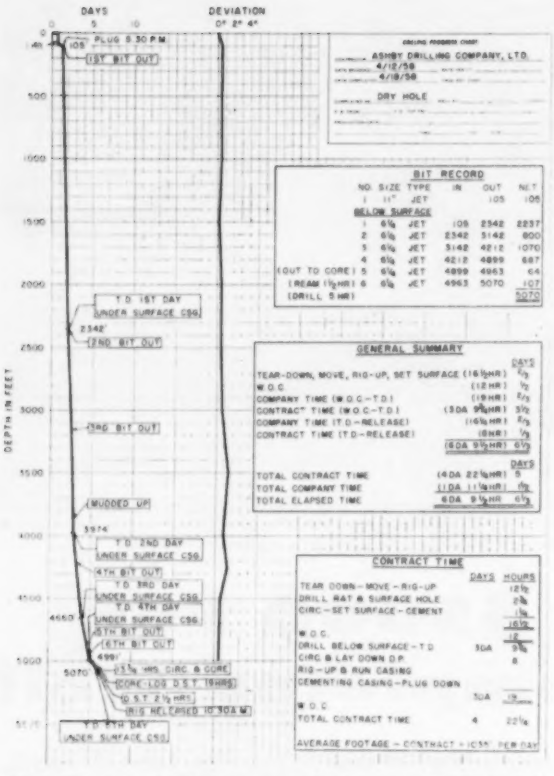


FIG. 2. **Slim hole drilling progress chart** for one 5070-ft dry hole in the Basin. Contract footage averaged 1035 ft per day. Total time from spud to rig release was only 5 days, 20 hours.

Many operators have recognized this saving and are drilling with reduced holes and completing with 4½-in. casing. They have had no difficulties in using small diameter pipe, and service companies in the area now have tools to work in these smaller holes and casing.

One major company in the Basin estimates costs at $20,000 for a dry hole and $60,000 for a completed well. Using the cost savings tabulated on the previous page, which are believed to be conservative, a cost reduction of almost 10 percent is possible.

Normal Drilling Procedures

Experience in drilling over 113 slim holes in the Denver-Julesburg Basin of Nebraska and Colorado have led to fairly definite drilling procedures which result in fast drilling and

TABLE 1. Savings in Drilling 38 Slim-Holes for One Company in the Denver-Julesburg Basin, Nebraska.

Savings—Slim Hole Over Conventional Drilling	
Contract footage	$ 99,701.00
Location, road & fill pits	7,000.00
Surface casing	11,700.00
Cement for surface casing	3,500.00
Drilling mud	10,500.00
Oil string casing	67,977.00
Cement for oil string casing	2,280.00
Trucking casing	3,940.00
	$206,598.00
Total footage drilled	228,316
Total elapsed days	516

76 days or 11.9 percent were saved in moving and rig-up time. Savings of 90 cents per ft on hole drilled compared to conventional programs.

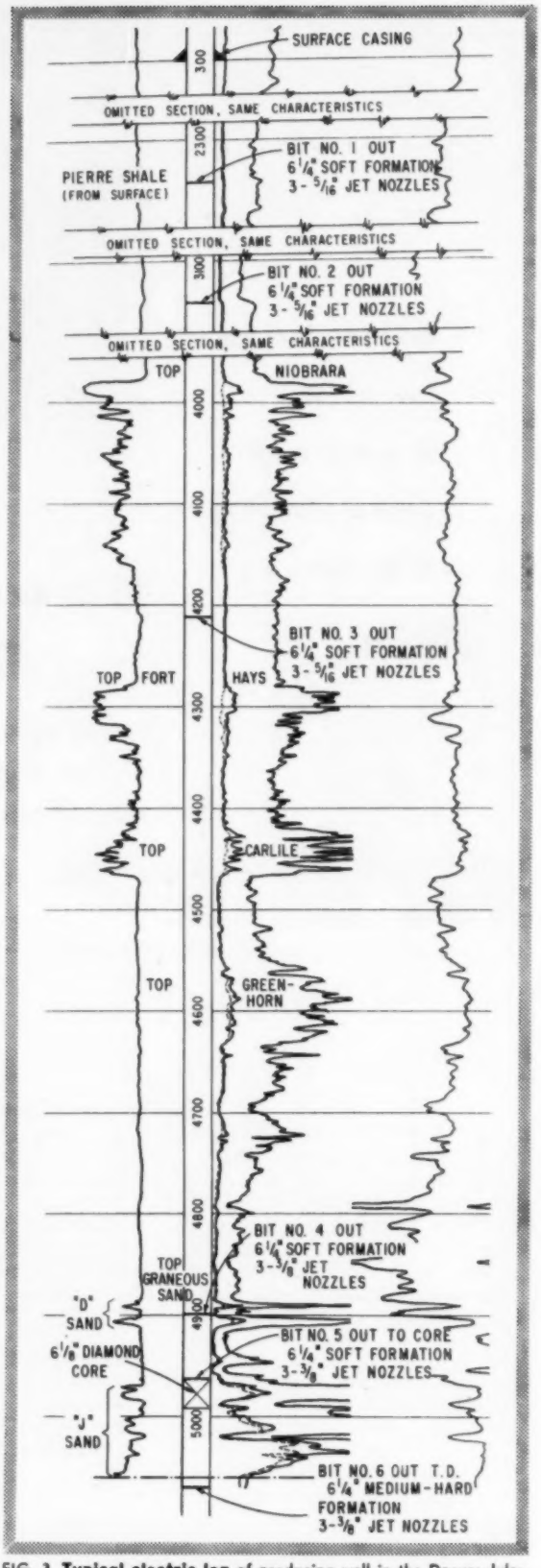


FIG. 3. **Typical electric log** of producing well in the Denver-Julesburg Basin showing formation tops and bit record.

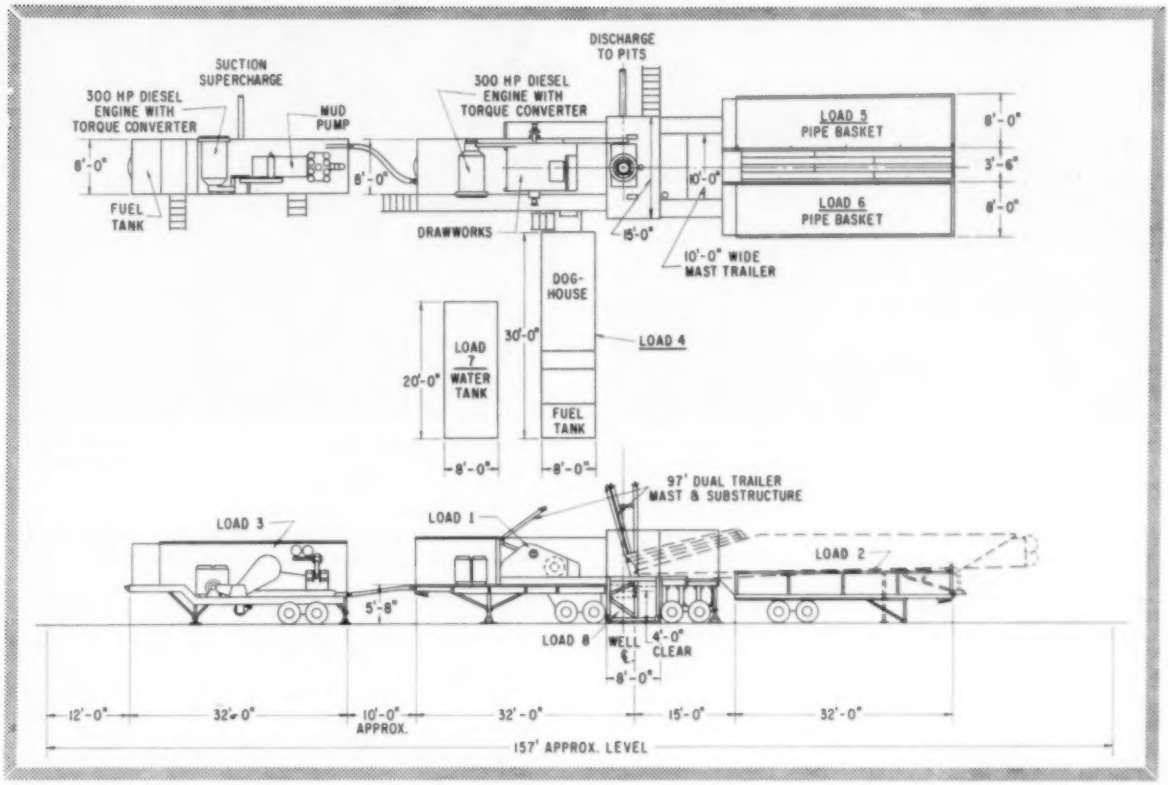


FIG. 4 **Layout and overall dimensions** of Ashby Drilling Company's Rigs No. 1 and No. 2, now active in the Basin area. Note portable features indicated by "Load Numbers"... with a total of only 8 truck loads to move entire rig.

an overall reduction in total days from spud to completion. Some of the salient features of the program include:

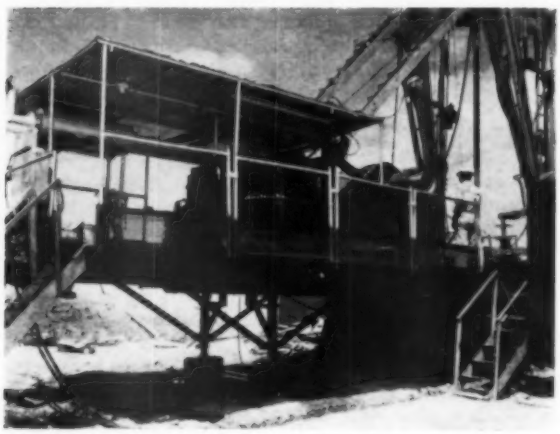
Earthen pits. Three are required and these are dug before the rig arrives on location. They include: One suction pit; one shale pit and one reserve pit.

Drilling fluids are trucked in from the previous well to make surface hole. While waiting on surface casing cement to set, all pits are jetted and cleaned, then filled with fresh water. Clear water is used as the drilling fluid from under the surface casing to nearly 4000 ft . . . or just above the top of the Niobrara Section, as shown in Fig. 3.

The hole is then mudded up with a fresh water-gel system containing 10 to 15 percent oil. Normal mud characteristics maintained are: Weight—about 10.1 lb per gal; viscosity—40 seconds API; water loss—3.5 cc. Mud weight is held as low as possible.

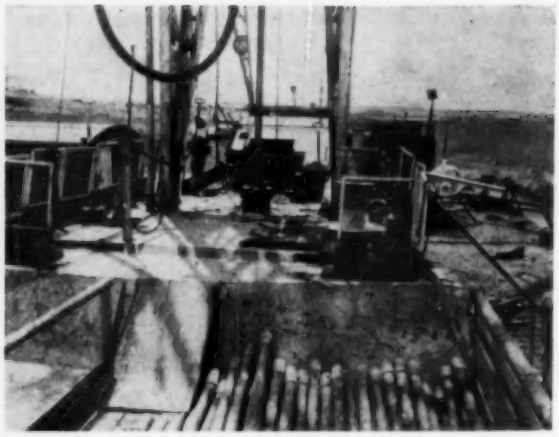
Drill string consists of twenty 5-in. by 2¼-in. bore drill collars with 4½-in. fishing necks and 3½-in. extra-hole box and pin connections; 15 joints or about 450 ft of 4-in. OD, 14-lb per ft, grade D drill pipe with 4½-in. OD 3½-in. extra hole tool joints. Remainder of the string is of 3½-in., 9.3-lb per ft, N-80 drill tubing wtih 4⅝-in. OD counter bore tool joints, 3½-in. internal flush, with wear bands.

The 4-in. OD pipe is used between the drill collars and

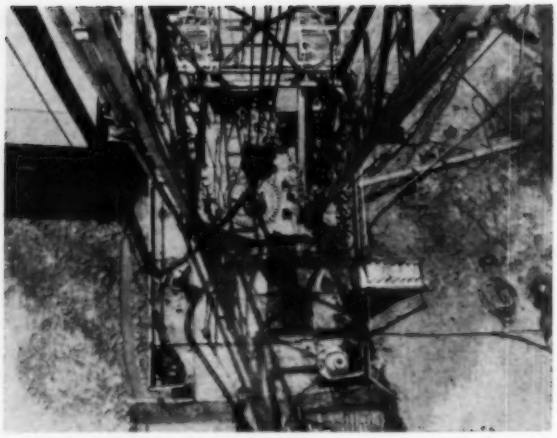


Drawworks trailer load backs up to derrick floor substructure, and is quickly disconnected for moving. Each rig is assigned three trucks.

Doghouse trailer equipped with two diesel-powered light plants, one 1000-gal fuel tank, clothes lockers, work bench and tool board.



Clear floor view by driller and all crew is demonstrated in view showing pipe storage "baskets" in foreground and drawworks in background. Doghouse trailer shown at extreme left.



Unitized floor section with minimum obstructions, complete package hookup from trailer to trailer facilitates slim hole rig moves.

the drill tubing to taper the mass and also to reduce wear on the drill tubing while making surface hole. One string of 4-in. drill pipe has been layed down after one failure in making 320,000 ft of hole.

A string of 3½-in. drill tubing has drilled 313,000 ft of hole without a failure and is still in service. Tool joints are counter-bore welded due to three "last engaged thread" failures in first string on the first hole drilled. Since counterbore welding the tool joints, the same string has drilled 242,000 ft of hole without a failure.

Rotary speeds. Until the 4-in. OD drill pipe is below the bottom of the surface casing string, rotary speed is held at about 100 rpm. Below this point, speed is increased to 200 rpm, then to 250 rpm until top of the "J" sand (see Fig. 3) is encountered . . . at which point the speed is reduced to 90 rpm.

Bit weight. While drilling to the top of the Niobrara (nearly 4000 ft), from 15,000 to 20,000 lb of weight is maintained on the bit. Below this point, bit weight is increased to 25,000-30,000 lb. Since the drill pipe is in suspension, bit weight is derived from drill collar weight.

Well deviation. Most operators in the area require well deviation surveys at 250 to 500-ft intervals. In 113 wells drilled, one well was skidded due to excessive deviation. This is a rarity, and was caused by excessive bit weight and failure to make deviation surveys at short intervals. One company in the area does not require straight hole tests.

Pump horsepower. In a 6000-ft 6¼-in. hole, 275 input hp is sufficient for good jet performance. This provides a nozzle velocity of 320 ft per second, and an annular return of 220 ft per min. Some conventional rigs have trouble with the bentonite sections yielding and causing a tight hole. In a 6¼-in. hole, this has never been noticeable. The mud pump is driven through a torque converter and 5¼-in. liners are used from top to bottom. The pump is run at a predetermined speed in order to keep gallonage up to minimum requirements.

Coring, Testing, Logging

Most operators on wildcats drill the well to total depth then log with any type or kind desired and then straddle-packer test the sections of interest. Most diamond coring is on follow-up wells for reservoir information.

In the event an oil string is run, centralizers and scratchers are used with 30 minute to 1 hour circulating before cementing. Float collars and shoes are used, and the collar is set below the zone to be perforated. Some operators keep the rig on the completion and run tubing, reverse out with oil, pull tubing, perforate, re-run tubing before releasing the rig. Other companies release the rig after pumping the plug down on casing and then complete with cable tools.

Highly Portable Rig Used

Trailer mounted rig. All equipment is trailer mounted except the sub-structure and water tank. The entire rig is moved in 6 trailers and 2 skidded loads (see Fig. 4).

Load 1: Drawworks trailer, 300 hp drawworks with diesel power, hydrobrake, small fuel tank, flooring, shed, windbreak, 17½-in. rotary table and wash down pump.

Load 2: Mast trailer, 97-ft, 300,000-lb capacity, complete with ⅞-in. drilling line, 100-ton, 3-sheave traveling block, crown, cat-line, flooring, windbreak, standpipe and rotary hose.

Load 3: Pump trailer, 300 hp pump supercharged with 6-in. centrifugal pump and powered by diesel engines, 1000-gal fuel tank, mud lines, shed and windbreaks.

Load 4: Doghouse trailer with two diesel powered light plants, 1000-gal fuel tank, clothes lockers, work bench and tool board.

Load 5 and 6: Two basket trailers with walks and laydown poles for all drill collars, drill pipe and drill tubing.

Load 7: 200-bbl skidded water-tank.

Load 8: Skidded sub-structure with mud line manifold built in, blow-out preventers and matting of ½-in. steel plate welded to bottom.

Aluminum is used for matting under trailer jacks, stairways and mud flow lines.

Each rig is assigned three trucks; one tandem and two single axle units. These are driven by rig crews. **The average time to tear down, move, rig-up and set surface casing on 113 wells is 33.7 hours and the average distance between wells being 38 miles.**

Future of Small Holes

One operator in the Basin saved $206,598 on 38 slim-hole wells drilled. Twenty-five were producers, in which 4½-in. oil string set (see Table 1).

There are some areas in the world, due to conditions and present production methods which still require conventional hole sizes and casing. However, there are numerous areas in which operating personnel can save their companies many dollars by careful planning and using reduced hole sizes and smaller casing.

The growing use of "slim-holes" can be seen by the increasing number of operators that are now switching over to 4½-in. casing. And, one major bit manufacturer states sales of smaller bit sizes are up in volume as compared to conventional sizes. ★ ★ ★

"Mist and Slug" is...

A New Technique in Air and Gas Drilling

A detergent injected with water behind compressors combats water intrusion. The foaming mixture can be slugged to handle large amount of water flow. Dry chemicals handle small amounts of water influx

F. W. Smith
Technical Drilling Service, Midland, Texas

WATER INTRUSION no longer determines the end point for air and gas drilling. A technique known as mist and slug drilling has extended the use of air and gas drilling beyond wet zones while maintaining dry drilling economics. The technique involves injecting into the air or gas stream certain chemicals which permit control of intruded water and continuation of air or gas drilling.

The success of the mudless drilling method has been proved in numerous applications. A well drilled recently in Pecos County, Texas, achieved a penetration of 8 ft per hr with clear water. With the conversion to mist drilling, the penetration rate was increased to 25 ft per hr. Another well in Pecos County was drilled to a total depth of 1600 ft using the mist drilling technique to handle water intrusion amounting to 20 bbl per hr encountered from 350 ft to total depth. A well in Lea County, New Mexico, was mist-drilled economically from 7500 ft to 9350 ft.

Another outstanding mist-drilled operation was a well drilled in Eddy County, New Mexico, which was drilled successfully from 4950 to 9430 ft. The well was making 2 bbl oil and 20 bbl salt water per hr, and gained five days on an offset gas-drilled well.

Mist and slug drilling techniques can be applied in any air or gas drilling operations where water intrusion into the well is not greater than 40 bbl per hr. Up to this point, the limiting factor is the type of formation open. Mist and slug drilling will not penetrate red beds or salt formations at any economical rate over mud drilling, and these formations erode rapidly. Most shale sections have stood up well under mist and slug drilling where no appreciable hydrostatic head is applied against the shale section.

Advantages

Several distinct advantages can be realized from mist and slug drilling. One of the most important is the increased penetration rate in most formations, along with an increase in bit life. Water and mud costs are eliminated, along with the problems of lost circulation and contamination of producing formations by invasion of drilling fluid filtrate. Observation of returns also provides, in effect, a continuous drill-stem test during drilling operations.

Disadvantages

Among the disadvantages encountered in mist and slug drilling is a decrease in penetration rate in red beds and salt formations, along with rapid erosion of these formations. Also, disposal of contaminated water can be a considerable problem. Present chemicals available economically limit efficient application of mist and slug drilling to wells flowing no more than 40 bbl water per hr. Influx of more than 20 bbl per hr of saturated salt water makes mist drilling uneconomical, as does more than 4 bbl oil per hr. It is expected that further study will result in chemicals which will broaden the limits of mist and slug drilling beyond those presently dictated by the type of fluid flowing into the hole.

Equipment

Equipment required for successful mist and slug drilling is essentially the same as that required for air drilling. The principal difference results from the higher pressure and volumes required in mist and slug drilling. The volume requirement of air, depending upon depth, will vary from 20 to 30 percent more than dry drilling, with pressure requirements up to 800 psi, varying directly with depth and water influx.

A dry chemical injector, capable of 350-psi operation, is manifolded into the air line. The dry chemical is used with water seepage of no more than 3 bbl per hr. A wet chemical pump is also manifolded into the air line to inject the foaming agent solution into the air stream. In order to handle water intrusion of 3 to 40 bbl per hr, the pump must be capable of injecting from 3 to 50 gal per min of foaming agent solution at pressures up to 800 psi.

Wellhead equipment used in mist drilling is the same as that used in air or gas drilling.

Chemicals

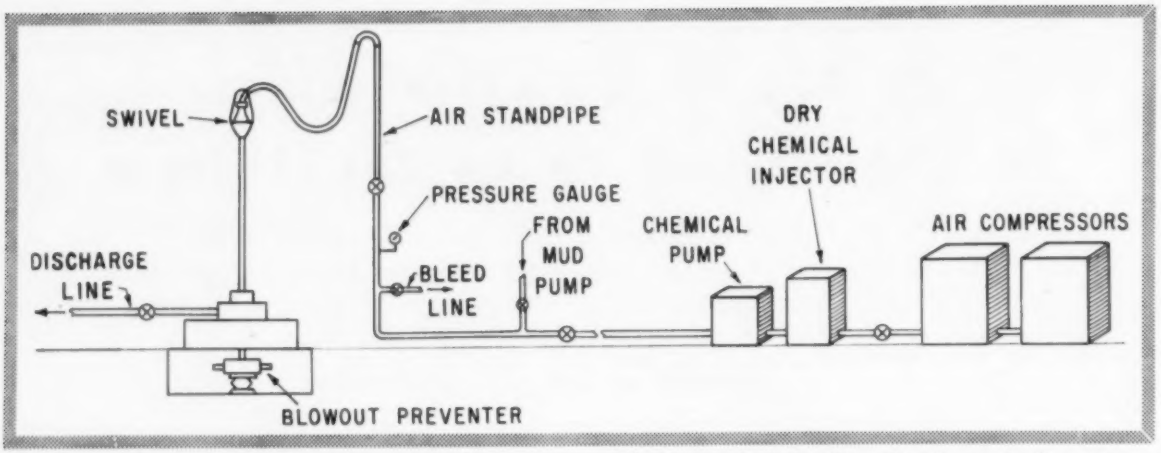
For water intrusion up to 3 bbl per hr, two dry chemicals are used. One is used to waterproof cuttings and the other is used as an absorbent. Both have deflocculating characteristics. The waterproofing chemical is a metallic stearate; the absorbent is a finely divided silica gel. For water influx greater than 3 bbl per hr, a detergent is used as a foaming agent.

To combat oxidation, corrosion inhibitors are added to the injection solution at the surface. Experimental work is being done with chemical additives for lubrication of bit bearings.

Applications

During air and gas drilling, the first indication that a fluid-producing zone has been penetrated is a decrease in the density of dust at the return flow line. The degree of decrease will depend, of course, upon the amount of fluid flowing into the hole, which will determine the proper method of treatment. Should the volume of dust decrease gradually, indicating a small flow of fluid, primary treatment will be with dry chemicals injected into the air stream at from 2 to 10 lb per hr. Surface indications of the success of the treatment will be a decrease in air pressure and increased returns at the flow line. Another indication will be the penetration rate: Should the dry chemical be insufficient to control the water, the bit will ball up and penetration rate decrease.

If water influx is such that the dry chemical treatment is unsuccessful, mist drilling is begun. Foaming agent solution is injected into the air stream and is continued until the bit has penetrated dry formations. Should the water influx be small enough, solution injection is discountinued and dry chemicals



Equipment used in mist and slug drilling is essentially the same as that required in air and gas drilling. A dry chemical injector is manifolded into the air line. A chemical pump is provided for injection of foaming agent solution. Connections from a standby mud pump are also provided.

are again introduced at a relatively high rate (10 lb per hr) into the air stream. Treatment is reduced at dust returns increase. In most cases where water intrusion is less than 3 bbl per hr, the water-bearing formation will be only 2 to 5 ft thick and the mist drilling technique will not be necessary to determine whether the dry chemical treatment will be satisfactory.

Sudden and complete stoppage of dust at the flow line would indicate water in excess of 3 bbl per hr and injection of the foaming agent solution would begin immediately. A general starting point for mist drilling is injection of 8 bbl of foaming agent solution per hr, the solution being a mixture of 1 gal of detergent with 8 bbl water and a corrosion inhibitor. The concentration and injection rate of solution will depend upon penetration rate, hole size, water influx, type of water, and the capacity of the air equipment.

It is found that maximum penetration rate and best bit life are obtained with minimum air pressure and full returns at the flow line. With changes in hole conditions, formations, volume of fluid intrusion, and type of fluid, the surface technique must be changed accordingly. It is impossible to outline exactly the volume of solution to inject into the air stream or the volume of air needed for mist drilling under varying hole conditions.

Depth of hole has a direct bearing on the horsepower required for mist drilling. To date, the deepest hole drilled with this technique was drilled to 9400 ft, and required 1600 air-compressor horsepower. The high horsepower was necessary to maintain high bottom-hole velocity and to insure a clean hole.

Most satisfactory results are obtained with a short tooth bit in soft formations and a carbide-tipped bit in hard formations. Short tooth bits drill small cuttings which require smaller volumes of air to lift to the surface. It will usually be noted that cuttings in mist drilling are larger than in straight air and gas drilling.

It is important that a bottom-hole float be run in the drill string. The float keeps the hole from back-flowing and plugging the bit, and allows a shorter time for making connections. A top-string float or check valve should also be run in conjunction with the bottom-hole float to provide a double check against back-flowing. The top float also reduces the time required for making connections.

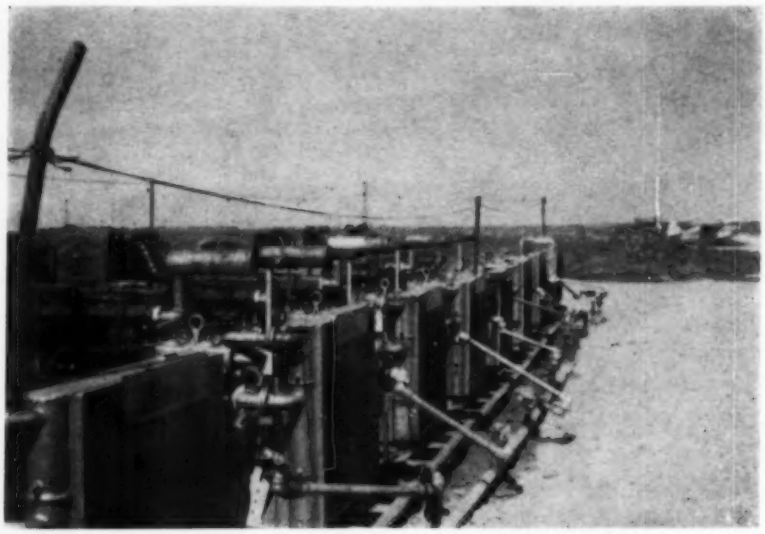
Bit weight and rotary table speed correspond to air and gas drilling. It has been found that penetration rate increases with an increase in weight on the bit. Crooked hole problems are handled as in a mud-drilled hole.

Corrosion

The corrosion problems encountered in mist and slug drilling are the same as those met in drilling with aerated mud. Saturated lime water (3 to 4 lb lime to 1 bbl water) is used with the foaming agent to maintain a pH of 10.5 or higher at the flow line. However, this treatment is satisfactory only when the fluid influx is fresh water. Also, large volumes of water dilute the lime solution, requiring continuous injection of saturated lime solution.

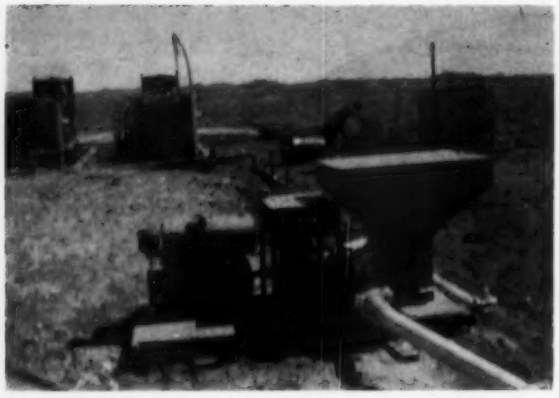
Commercial corrosion inhibitors are being used satisfactorily where fresh, salt, and sulfur water are being handled. The proper selection of an inhibitor is critical in that it must be compatible with the foaming agent.

Provisions must be made to handle well fluids. In most cases, the reserve or a small pit will be satisfactory. In some cases, the returned fluid can be

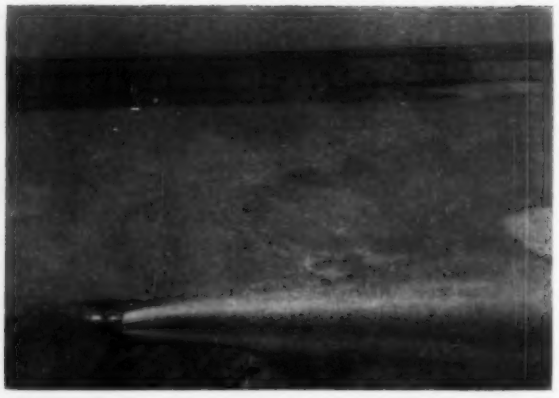


Bank of eight compressors used in one mist and slug drilling project. Air requirements in this technique are generally greater than in straight air or gas drilling.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Injection equipment includes (foreground) a dry chemical injector capable of 350-psi operation manifolded into the air line. A chemical pump (right, background) injects foaming agent solution.



Return line provides constant check of mist or slug drilling progress. Nature and volume of returns from air drilling determine when to start or stop mist and slug drilling.

recycled after the solids have precipitated.

Maintaining a clean hole in mist drilling is more critical than in fluid drilling. Undesirable hole conditions are indicated at the surface by excessive torque, dragging when pipe is worked, incomplete returns of air and cuttings, high air pressure, and reduced penetration rate. To combat these conditions, changes in air volume and injected solution are necessary.

When an oil-bearing formation is penetrated, the system is defoamed in most cases. To offset the action of the oil, concentration of the foaming agent is increased, or a different type foaming agent is used. Should water influx be too great (in excess of 40 bbl per hr), a squeeze job could allow continued use of mist drilling. A 100 percent successful squeeze would allow return to dry drilling. The possible savings to the mud-up point would be the determining factor in considering a squeeze job. Cement has been used with satisfactory results and some work has been done with plastics.

Geological data from the well are very important in realizing the full economy of mist drilling. These data determine the type bits and chemicals which should be used, as well as proper squeeze or mud-up points.

Mudding Up

Hole conditions dictate the method of mudding up an air, gas or mist-drilled well. The most common procedure is to pump a good low-water-loss mud with the bit on bottom. Enough storage must be provided to circulate the system completely. Another method of mudding up the hole is to pull the drill pipe 1000 ft at a time, pumping in mud to fill each 1000 ft interval. When the bit is inside casing, the hole can be loaded completely to the surface.

After the mud has set on the formation a few hours, the bit is run back into the hole 1000 ft and circulation is established. After circulating the hole sufficiently to clean out any cuttings or sloughings, the pipe is run in another 1000 ft and the same procedure is repeated until the bit reaches bottom.

Safety considerations require that at least one mud pump be kept on standby during mist and slug drilling operations, as in dry drilling. If a high volume gas zone is penetrated, the blowout preventer should not be closed before mud is being pumped into the hole.

Mist and slug drilling extends the use of air and gas drilling to many new areas and new sections in dry drilling areas. To improve techniques, more adaptable and efficient air compressors are needed. Further study of chemicals is required to develop a foaming agent effective with high influx of oil and salt water and which incorporates economically a satisfactory corrosion inhibitor and bit lubricant. While impressive savings can be realized from increased penetration rates and better bit life, economic benefits of mist and slug drilling are lessened by chemical costs and the additional equipment required. * * *

Pyle Elected 1959 AIME President

The American Institute of Mining, Metallurgical, and Petroleum Engineers has elected Howard C. Pyle, of Los Angeles, as president to take office for one year beginning at the AIME annual meeting in San Francisco in February 1959. Dr. Augustus B. Kinzel, of New York, is current president.

Pyle is president of Monterey Oil Company. Dr. Kinzel is vice president-research, Union Carbide Corporation. Election of Pyle and of other officers and directors was announced at a recent meeting of the AIME board of directors.

These include Dr. Joseph L. Gillson, of Wilmington, Delaware, chief geologist of E. I. du Pont de Nemours & Company, to become president-elect, pointing to the AIME Presidency in 1960 following Pyle's term.

Others are: Vice President—Thomas C. Frick, Lafayette, Louisiana, regional manager, Atlantic Refining Company.

Vice President—Dr. Walter R. Hibbard, Jr., Schenectady, New York, manager, alloy studies research, General Electric, now president of Metallurgical Society of AIME.

Vice President—Elmer A. Jones, Bonne Terre, Missouri, division manager, St. Joseph Lead Company, former president of the Society of Mining Engineers of AIME.

Vice President—John C. Kinnear, Jr., McGill, Nevada, general manager, Nevada Mines Division, Kennecott Copper Company, former president of The Metallurgical Society.

Vice presidents have been named for one year. New directors named for three years, will be:

John S. Bell, Los Angeles, area manager, Humble Oil & Refining Company, who is president-elect 1959 of the Society of Petroleum Engineers of AIME; Dr. John C. Chipman, Massachusetts Institute of Technology, who will become president of the Metallurgical Society in February; Dr. Arthur B. Cummins, Manville, New Jersey, manager, central chemical and physical research department, Johns-Manville Research Center; Dr. Carleton C. Long, research director, St. Joseph Lead Company, Monaca, Pennsylvania, who will become vice president of The Metallurgical Society in February, pointing to its presidency in 1960; Jerome W. Woomer, Pittsburgh consultant, who in February also will become president of the Society of Mining Engineers. * * *

ANOTHER REASON WHY SECURITY BITS PACE THE INDUSTRY:

Security's higher bearing standards give your bits more muscle!

Bottom-hole view of Security's H7W, for very hard, abrasive formations.

Security's *matched set* of roller bearings have *identical* lengths and end diameters to + or — .0001". Each hour, Security's electronic inspector-sorter checks 16,800 bearing characteristics automatically.

Roller bearings are the heart of any rock bit. Oversize, undersize, or mis-matched bearings play havoc with your drilling. Put a Security bit on your string every time, and you run a precision *matched set* of roller bearings.

Security's electronic inspector-sorter — developed to Security specifications by RCA — automatically gauges bearing length, and both end diameters to a plus or minus tolerance of .0001". Only bearings meeting these specifications are used in Security bits. This means that in every Security bit you get matched, correct-size bearings that work together smoothly without tendency to bind or twist or stick when you are making hole.

This is one of the many ways Security paces the industry in producing quality, long-life rock bits — helps you cut drilling costs, make hole faster. Next time put a modern Security bit to work for you *and put more muscle in your drilling.*

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Electronic inspector-sorter gauges Security roller bearings to plus or minus .0001". Automatically rejects oversizes and undersizes. Further grades approved bearings into matched groups of "plus sizes" and "minus sizes" within tolerance specifications. Assures *matched bearings* for every Security rock bit furnished the industry.

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John Rundle, vice president of operations, answers most-asked questions concerning Loffland Brothers foreign work, and the . . .

Overseas Opportunity in Contract Drilling

Years of successful operations abroad attributed to teams of specialists, experience, sound investments . . . and ability to offer contract bids in every conceivable form . . . with a myriad of services

AT A TIME when many contractors are still talking about foreign drilling, Loffland Brothers Company is operating in 10 countries outside the continental boundaries of the U. S.

Loffland Brothers, the biggest contractor of them all, has penetrated the soil in nearly all oil producing states in the Union and, since 1943, has been actively engaged in foreign operations. In that year, Loffland Brothers moved a rig to Prince Edward Island in eastern Canada to drill a 14,000-ft hole for Socony-Vacuum Oil Company.

The organization is now international in scope. It has contract representatives in six cities outside the States.

Growth in this direction is one thing — to be successful, as has Loffland, is another. This success is largely the result of the close knit organization and carefully planned expansion within the Loffland group. Coordinating the work is John Rundle, vice president of operations.

John Rundle joined Loffland Brothers some 27 years ago as a roughneck, when the company had only six or seven rigs. Since that time he has served in various positions with Loffland and has come to be known as one of the foremost authorities in international operations.

Explaining the company's many foreign ventures, Mr. Rundle had these comments to questions during an exclusive PETROLEUM ENGINEER interview.

Q: *How is Loffland's international organization set up? . . . that is, what does the organization chart look like? How many are involved in administrative work as compared to those actually engaged in the drilling operations? How does this compare with domestic drilling operations? Under what circumstances are subsidiary companies set up?*

A: The operations of Loffland Brothers are carried on through seven different companies operating under the "Loffland Brothers" name. Where the scope or size of operations justify it, we have division and district levels within these different companies. These divisions or district echelons are fully manned to give an independent integrated operation. That is, each sub-group has a manager, with one or more assistant managers, and other necessary administrative and office personnel. It's only in the field of major policy matters pertaining to such things affecting financing, accounting, insurance, taxes, and personnel policies that the home office exercises any significant control. Often, too, this is handled more in an advisory manner, than a true decision making capacity.

In the true administrative level, there is no significant difference in the number of people required as compared to the domestic organization. However, depending upon the requirements of the operation, the scope of responsibility of individuals within the administrative group may be significantly different than what is found in the domestic operation.

There is a variety of reasons for setting up a subsidiary company. Generally such decisions revolve around local custom or laws, tax and currency matters.

Q: *Loffland can be proud of the fact that the average well it drills is twice the U. S. average well depth. In what depth classification does most foreign drilling fall?*

A: All depths—but tendency of most exploratory drilling in new foreign areas is 10 to 14,000 ft. At least, equipment of that capacity is used, just to be on the safe side.

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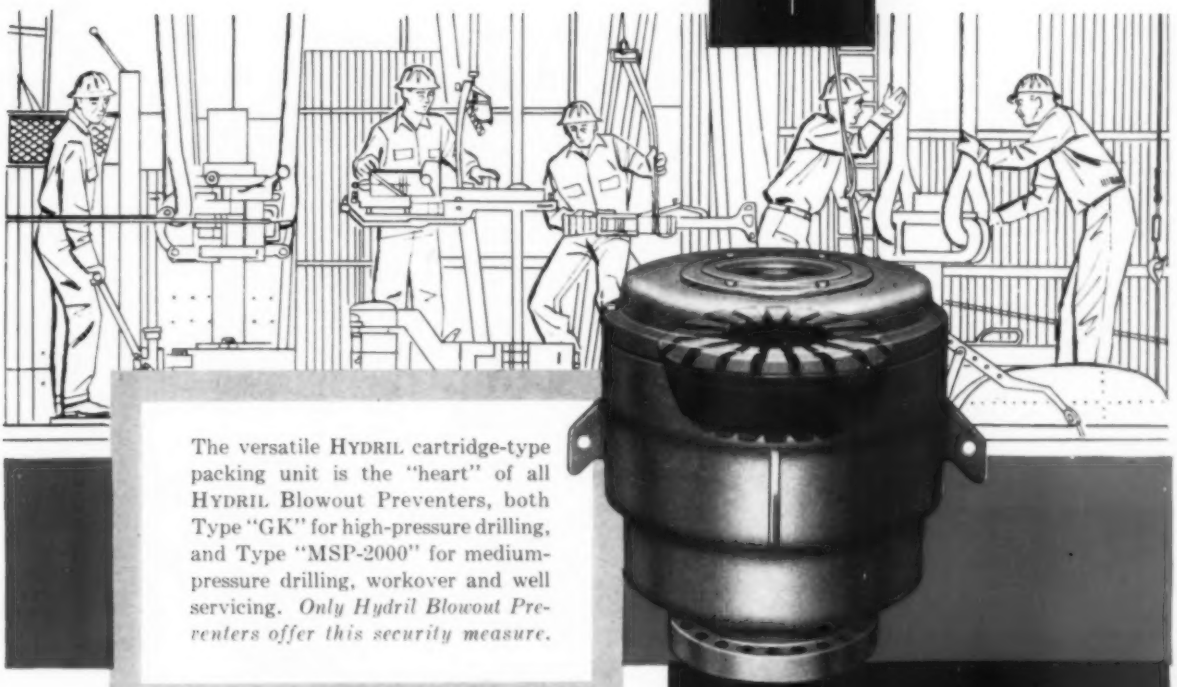

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And the Baker Serviceman, who knows his business because Baker Tools are his *only* business, is always available. His knowledge of local field conditions enables him to make sound recommendations for operations in your well. It pays to start right by calling Baker!

BAKER RETRIEVABLE BRIDGE PLUGS are dependable, and they hold pressure from either direction. Used alone for plugging casing temporarily under routine or emergency condition, or in combination with other Baker RETRIEVABLE Tools to straddle a virtually unlimited interval. Call for Product No. 677-C.

BAKER FULL-BORE TUBING TESTERS are run with Baker FULL-BORE Retrievable Cementers for safe testing of tubing immediately before squeezing. Right-hand rotation required for setting the Cementer, serves to unlock the Tester Valve; set-down weight closes it; picking-up after testing restores full-opening through the Tester. Call for Product No. 672-N.

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BAKER CEMENT RETAINERS provide the most positive seal possible, with opposed slips that hold securely from either direction. Both the CAST-IRON Type and the MAGNESIUM Type are **readily drillable.** Set on wire line, tubing or drill pipe for a wide range of squeeze operations. Call for Product No. 400.

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BAKER OIL TOOLS, INC.

HOUSTON LOS ANGELES NEW YORK

" 'Here today, gone tomorrow' could well be epitaph" to a foreign contractors' business

Q: *How many wells outside the U. S. has Loffland drilled? How does this stack up with other contractors?*

A: From January 1946 through March 1958 Loffland drilled 759 wells in foreign countries, excluding Canada, for a total of 5,567,994 ft or an average of 7336 ft per well. During the same years Loffland domestic company drilled 3441 wells, total footage 29,115,213, or an average of 8461 ft each, in the USA. This is believed to be considerably more than any other contractor's experience.

Q: *What's the first step a contractor must take in his search for business outside the U.S.? Does it involve negotiating first and later working out your own operating problems? Does this mean you must have a "diplomatic corps" to investigate and study those areas or countries where drilling is contemplated?*

A: A contractor attempting to obtain foreign drilling work must have an organization sufficiently staffed with representatives familiar with problems existing in any given area where companies may have plans for drilling operations, so that a proposal may be submitted that will take into consideration an accurate evaluation of all operating problems and costs. Generally, and if the customer permits the time, we thoroughly analyse and submit for consideration every phase of the operating problems that may be presented in a new area.

We don't send a "diplomatic corp," we send highly qualified individuals, who, through years of experience, know what to look for and what information is needed.

Q: *After you have negotiated an overseas drilling contract, what are the next steps involved so far as getting the operation started? Is it a matter of applying to the State Department for export licenses, etc.? How about the other end of the line if the work involves shipping all equipment to a new country?*

A: Generally, if we are negotiating a contract, many steps have already taken place in anticipation of receiving the job. After a job is awarded, there's no true "next step" as far as we are concerned. Also, it depends upon the country involved as to what different matters are required. Sometimes you need to apply for an export license. In some cases we maintain a blanket license. A foreign country's requirements for shipments to their country are about as varied as the number of countries involved.

Q: *Is there any pattern for negotiating overseas drilling contracts? Such as cost-plus, footage, so much per day, etc. In general, what does Loffland offer in the way of services to take advantage of increasing foreign drilling activity? Does the company offer package deals (drill, test, place the well "on the line")?*

A: Every possible combination of bids are made. We currently have in progress footage, daywork, combination, cost-plus, both straight labor and labor plus equipment. In some cases the equipment is limited to the rig only. In other cases complete facilities including rig, camps, transportation and road construction, warehouse, shops, etc., are offered. This can even extend to investment in schools. Loffland Brothers offers the broadest kind of service. We have separate departments, run by specialists in their field, in purchasing, engineering, traffic, safety, law, personnel, accounting, equipment maintenance and design, tax, labor relations, insurance, financing, and, of course, drilling supervisors. Behind these departments are years of experience in handling foreign operations under almost any circumstance, and of any type — onshore, offshore, jungle, desert, mountains, and ice. Service companies as we are familiar with in the States are often not represented in foreign areas. We furnish mud engineers at times. We run casing strings, squeeze cement, run about any kind of test or completion tools without the use of service companies. We have and will offer package deals—but as a rule our customers don't request a contractor to do it.

Q: *Suppose you have negotiated a contract with an oil company to drill a specified number of wells in a given part of the world, what would you say is the biggest obstacle in executing the contract? Is it the "red tape" involved in getting men and materials and equipment to the location to commence drilling, or is it one of logistics? Personnel?*

A: After so many years in foreign operations, we feel we have managed to resolve all the "obstacles." By comparison to domestic operations, however, a foreign operation requires great emphasis on coordination. Mistakes and inexperienced management are extremely expensive to the operator. Personnel not experienced in foreign operations would be a major headache. Sending a man

Crowds gather at Loffland-drilled Australian well.

for the first time on a foreign job presents problems. Fortunately, because of our scope of operations, we have men who can be sent from more developed areas of foreign activity into the rougher jobs. The inexperienced man can then fill the vacancy. This is acclimation by degrees, and we feel a very big help in adjusting a man for his new experiences. It gives us the opportunity to offer the highest quality of personnel.

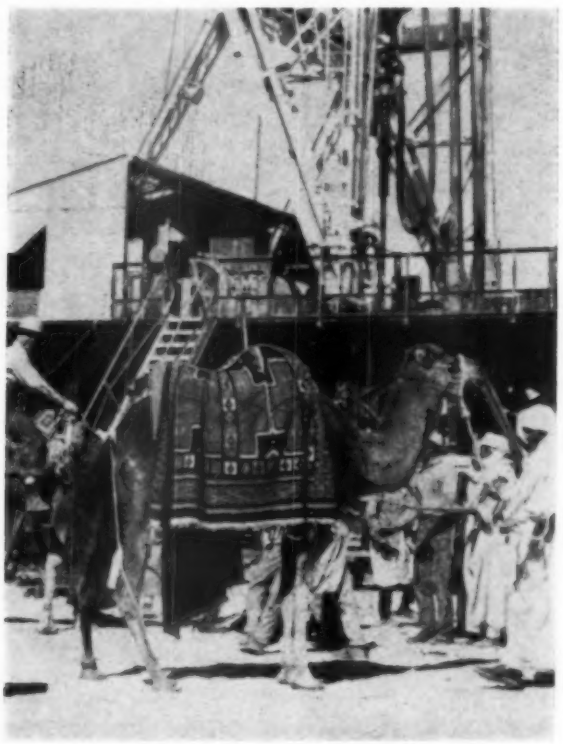
Q: *How is financing usually handled in foreign contract work? Does the operator (either an oil company or foreign government) pay a reasonable amount in advance, or are monthly payments involved?*

A: Generally, monthly payments are involved. If the operator is of undeterminable credit risk, we require some kind of guarantee. Where our customer may be a foreign government in a dollar-short country, they fully understand the problem, and a contractor can usually work out the financing on a sound businesslike basis. However, if one does not fully understand the technicalities of this type of financing, it will be difficult for him to realize the risks he is taking, and he is prone to be lenient beyond the dictates of sound business practice.

Q: *What is involved in this matter of foreign exchange: Is it a problem to convert foreign currency into U.S. dollars?*

A: It depends on the currency you are talking about. Some currencies are subject to severe fluctuations in value. Also, a study of living cost indexes in some countries will point out otherwise overlooked possible currency problems.

Q: *Recognizing that there is considerable difference in the cost of drilling from one foreign country to another . . . what would be your estimate as to how many times more expensive is it to operate drilling operations abroad as compared to U.S. drilling operations? Five times as much? Ten?*



Camels study Loffland's rig in Libyan desert.

"Glamour in foreign operations is sometimes mistaken for unlimited opportunity"

A: Due to the entirely different method of operation usually surrounding a foreign job, as compared to domestic operations, there would be no fair comparison. Suffice it to say it is more expensive — usually considerably more expensive.

Q: *Is there any trend toward price-cutting in contract drilling abroad? Is there competition from foreign drilling contractors?*

A: We do know of cases where prices have been quoted below what the comparable work would bring in the United States even under present conditions. However, we do not think of it in terms of "price-cutting" as much as failing to know their costs.

Q: *What are the financial risks on the part of a U.S. drilling contractor in foreign operations? Is there any protection to be expected by our government to protect a U.S. contractor, his employees and his equipment in a foreign country?*

A: Financial risks are greater because you are subject to changes in taxation, regulations and laws of a foreign sovereign state or labor unions over neither of which the U.S. government has any jurisdiction.

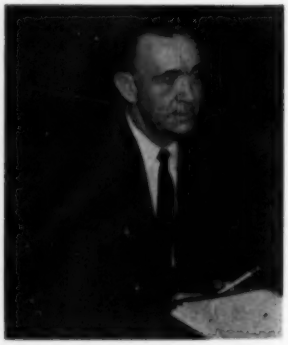
American contractor's personnel are given the same protection, or rather assistance, by the U.S. consuls as they give any other Americans living or traveling in the country. Certainly, they do not enjoy diplomatic immunity, but are subject to all the laws and penalties that the national is and, in many countries, more.

The contractor may also run the risk of expropriation, confiscation, or sabatoge of his equipment. After enjoying the freedoms and political stability of this country, a newcomer will find it hard to realize the dangers and risks involved. "Here today and gone tomorrow" could well be the epitaph to his business. A study of the country's history in this regard brings out some surprises, even though things look rosy today.

Q: *How about this matter of insurance? What type of insurance is involved for your own employees sent abroad? On equipment? Is any insurance available in foreign countries comparable to our blowout insurance? Or other operational insurance, such as accident insurance? What other protection is offered the contractor employee in foreign drilling?*

A: We offer our employees going abroad the same protection as they would have under the State of Texas Workmen's Compensation Laws or the Workmen's Compensation Laws in the country that they are working; whichever is better.

Most generally all of our insurance is carried through private companies qualified to do business in the various foreign countries in which we are operating. We have



Price Cutting: "We do know of cases . . . however, we do not think of it in (those) terms, as much as failing to know their costs"

encountered a few countries whereby various types of insurance have to be written with department of the government set up specifically as insurers. For other protection which we offer for our expatriate employees besides being protected fully for medical expenses due to accidents, we also pay most medical expenses incurred by sickness, and under some conditions afford some contribution toward payment of medical bills incurred by their families.

Q: *How do you pay your overseas employees? Do they have the choice of getting so much in foreign currency and having the remainder deposited in some U.S. bank? What is the employee up against in the matter of income tax, both U.S. and in the particular country in which he might be working?*

A: American employees may receive a portion of their salary in local currency. The employee's tax liability is based upon his length of stay in the foreign country. The details are quite long, but if he stays long enough, he will be free of U.S. tax liability.

Q: *How do income taxes affect the drilling contractor company who operates abroad? Is he also subject to U.S. income taxes as well as those in the country where he operates? What type of reports must be filed each year with the U.S. Internal Revenue Department by a contractor doing business in other countries?*

A: Answers to all of these questions depend upon the corporate structure of the contractor and the country in which he is operating. There are many, many variations and it requires considerable study to select the most satisfactory approach. And, of course, the most satisfactory approach tax-wise may not be the best in other matters. It depends on what you want to place the greatest emphasis — tax, currency, investment, or legal protection.

Q: *It has been reported earlier this year that one contractor expects between 30 and 35 percent profit in order to justify the risks and heavy administration costs involved in foreign contract drilling. Do you care to comment on this?*

A: Higher risks, and the greater know-how certainly justify higher returns. I don't believe any contractor should go into foreign work anticipating that he is going to make this kind of profit — even though he might "expect" it. For the number of jobs available, competition is just as great in foreign work as in domestic.

Q: *What percent of employees in foreign service are "nationals?" Is there a large turnover? Are U.S. employees abroad rotated back to the U.S.?*

A: Laws of the country sometimes establish this percentage. In Venezuela, for example, you are required to maintain a fixed percentage. Generally speaking the average ranges from 75 to 85 percent. It is always our objective to employ and train nationals to take over jobs when they become qualified. Generally, more people must be assigned to a particular job than would be thought necessary. This is brought on, either by the local laws, or by the fact that the national has not yet had the opportunity to gain the experience and training necessary.

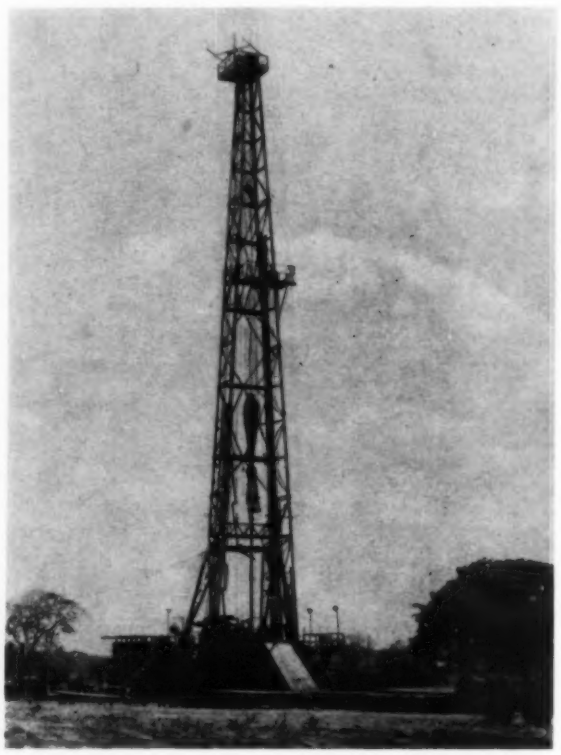
A national employee values his job as much as anyone and turnover is generally no more than in domestic operations. However, it requires experience in understanding the local laws, customs and thinking to keep the employee satisfied and develop a stable work group.

All employees, whether working domestic or foreign, are treated as members of the Loffland organization and there is a comparatively high degree of exchange between domestic and foreign work. In this way, we keep a reserve of experienced personnel available at all times to move into foreign work.

Q: *What type of growth pattern for Loffland do you foresee in foreign contract drilling?*

A: Foreign drilling activity is certainly not a cure-all for domestic slack. As a matter of fact, since most of our work is with major oil companies, when budgets get cut, usually everyone feels the blow, domestic and foreign alike.

There is always a lot of glamour associated with thoughts about foreign operations. This glamour is sometimes mistaken for unlimited opportunity. Potentials are always over-estimated by the over-zealous without a look at the cold hard facts. Cases in point would be the overenthusiasm and resulting premature expansion beyond demands for equipment in the offshore United States and in Venezuela. Loffland Brothers is prepared to expand their foreign investments on a sound basis built on facts. ★ ★ ★



Drilling in Venezuela is "old hat" to Loffland.

New data on...

FLUID KNOCK IN MUD PUMPS...

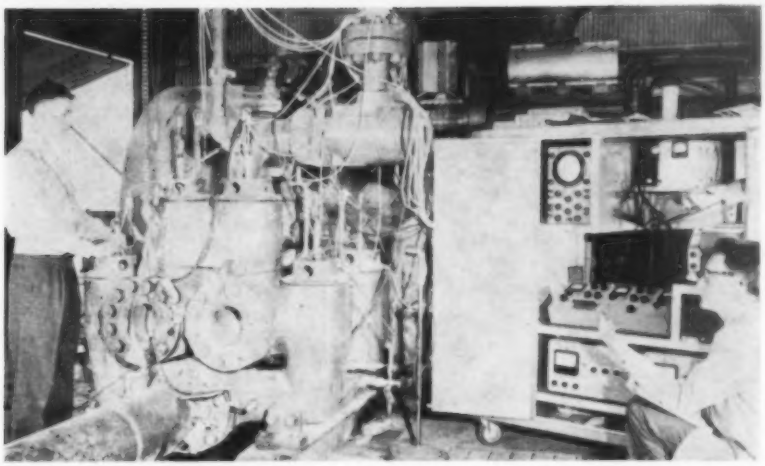


FIG. 1. **Mud pump test hookup** showing complete instrumentation used in detailed investigation of fluid end of pump.

isolates basic causes and suggests corrective measures. Intricate instrumentation and detail lab investigation provided the answers

Samuel L. Collier,
Houston Manufacturing Company, Houston, Texas

MOST of the sounds or knocks emanating from an oilfield mud pump are mechanical and are relatively easy to isolate. One sound sometimes identified as valve knock is not as well understood. Various detail experiments were made to establish definite characteristics of this knock. These include valve behavior, fluctuation of pump suction pressure, variation of velocity in the suction and speed of propagation of the suction pressure waves. **These tests established the fact that this is a hydraulic knock and that it occurs when the pump operation causes the development of a void in the cylinder. When the void is filled, usually just past mid-stroke, the liquid strikes the piston causing a hydraulic shock wave and loud knock.**

Isolating the "knock." In order to make a complete analysis of fluid knock in mud pumps, it is necessary to have both completely controllable equipment and high-response instrumentation that will record the factors involved.

The 5½-in. by 14-in. duplex pump used in the investigation and the instrumentation hookup are shown in Fig. 1.

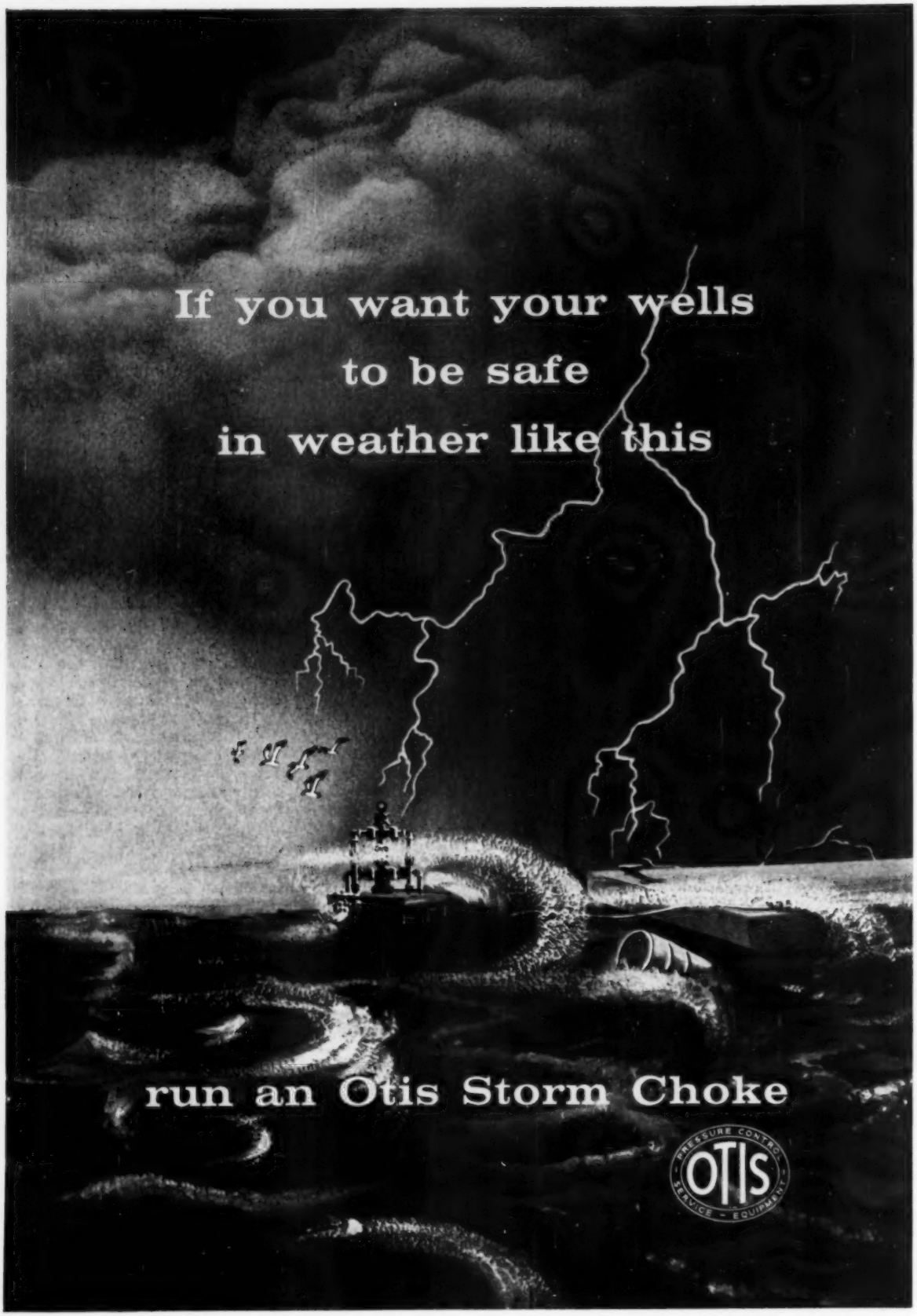
Presented at the ASME Petroleum Mechanical Conference, September 21-24, 1958, Denver, Colorado, under original title "Fluid Knock in Oil Field Mud Pumps Due to Separation."

Many sounds emanate from an oilfield pump while it is in operation. Most of the abnormal sounds develop because of abnormal operating conditions. One of these sounds has been described as valve hammer, knock, or fluid hammer. This study is concerned with the development of a hammer blow as compared to various less intense sounds that might be regarded as thuds rather than knocks. The oscillograph record of this sound (Trace 13, Fig. 3) shows that the sound level rises significantly under these circumstances while the various other sounds have significantly smaller variations. Investigating equipment makes possible the study on a cathode ray oscilloscope and recording on the oscillograph the envelope of sound intensity and the complete trace showing all frequencies. However, the sound does have a great increase in power at the instant of knock and it is unnecessary to sort it by frequency.

Effect of suction pressure. One of the most obvious connections with this hammering sound when records are made with high fidelity equipment shows up in the suction pressure trace. Normal surges in suction pressure occur with a dependence on piston velocity, but when hammering is in progress the surge is far out of proportion to piston velocity. It is much larger than normal. For example, the normal suction pressure surge (Trace 2, Fig. 2) has a peak of 23 psi while the abnormal surge (Trace 2, Fig. 3) has a peak of 76 psi. When the variation in suction surge pressure is plotted against suction velocity as influenced either by pump speed or by liner size, a linear relation is not obtained. For example, in the case of a change in liner size, a 7½-in. liner handles nearly two times the fluid as a 5½-in. piston and liner so the suction velocity must be twice as high and the abnormal surge should occur at a much lower speed, if it depends on suction velocity. However, it actually occurs at only a slightly lower speed.

Suction valve behavior is another phenomena occurring during hammering that seems quite significant. Trace 10, Fig. 2, is a typical curve for the suction valve motion during normal operation. This curve is regular except for slight flutter and it approximates the rate of flow which varies with piston velocity. Trace 3, Fig. 3, is the discharge valve motion.

Discharge valves are not disturbed during this hammering while the suction valve behavior becomes abnormal, therefore, knocking should occur in the suction system rather than in the discharge system. This knock sometimes has been called valve hammer, but these tests show that under knocking conditions the noise occurs when the valve has ample lift so that the stem does not strike the top guide. In addition, the change in valve motion and great increase in sound intensity (Trace 13) occurs in mid-stroke when the valve is open and not at the end of


If you want your wells
to be safe
in weather like this
run an Otis Storm Choke
PRESSURE CONTROL
OTIS
SERVICE - EQUIPMENT

Rockwell-Nordstrom Valve stocks like these are typical of the line of quality equipment distributed through National's 130 stores.

This is the National Supply Store, too

This is a view of Rockwell-Nordstrom Valve stocks in the part of a National Supply Store you may not often see. You can see these and other quality products as often as you choose, because you're *always* welcome in our store, warehouse, equipment yard or pump shop. The doors are always open, and it will pay you to walk in and get better acquainted with our store people and the stocks they offer. We've built counters in our stores for convenience—not as barriers.

As you walk back and around, you'll see equipment like these Rockwell-Nordstrom Valves . . . Oilmaster Pumps . . . Tube-Turn fittings . . . Ajax Engines . . . Link-Belt Chain. The list of outstanding equipment is a long one, and we're pleased to be associated with every name on it.

More important, it's equipment we know you can use to operate profitably. Having it ready for you, when and where you need it, is our business, and we have 70 years of experience in it.

The next time you stop in a National Supply Store, remember to shop behind the counter, too.

A National F-90 Triplex Pump installation in Texas. You can profitably use National Triplex Pumps on a host of oilfield pumping jobs including waterflooding, salt water disposals, and as power-oil sources for subsurface hydraulic pumps.

Only National Triplex Pumps have all 15 of these features!

Here they are—15 construction features combined only in National Triplex Pumps.

1. Connecting rods equipped with steel backed babbitt lined precision bearing shells.
2. Fluid ends of special alloy for maximum corrosion resistance or non-corrosive service are available for both high and low pressure.
3. Close end clearances in the fluid end plunger cavity, promoting best filling, improving volumetric efficiency and reducing shock and vibration on pump and manifolding.
4. Removable stuffing box cartridges* and plungers make conversion from one size to another possible through use of plunger kits at minimum cost.
5. All packing easily reached for adjustment.
6. A variety of plungers are available for either corrosive or non-corrosive service. All are ground to the finest finish to give the longest plunger and packing life.

* Patent Pending

7. Stainless steel disc-type valves, giving maximum corrosion resistance and having light moving parts, thus reducing inertia and allowing maximum fluid filling.

8. Suction valves removable through cylinder heads, which allows installation of valves in a single valve pot without complications of valve spacing devices, and maintains interchangeability of all valves. Makes possible straight through fluid flow with minimum end clearance.

9. Low suction elements, assuring better suction conditions than with a vertical pump.

10. Coordinated design of suction passages, valve areas and end clearances, improving fluid filling and permitting higher speed operations.

11. Lubrication of all power end parts is accomplished by a directed splash system. Deflectors positioned in the power frame direct the splash to built-in reservoirs which in turn deliver oil to the moving parts. (On the F-90 Triplex Pump, a pressure lubrication system, as well as a splash lubrication system, is standard.)

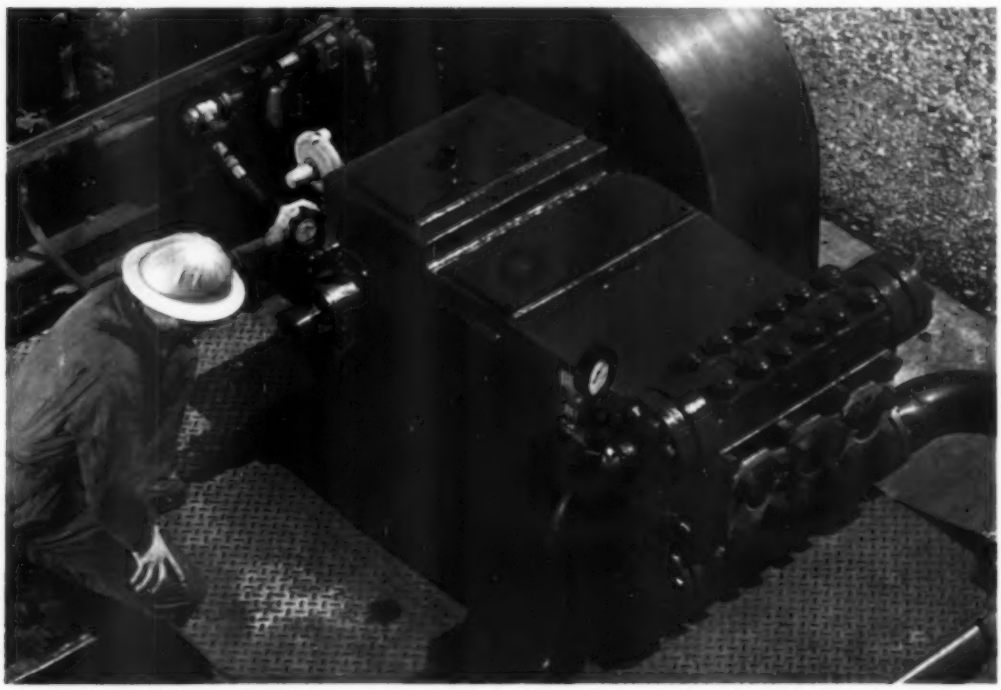
12. Horizontal design gives larger support area as well as lower center of gravity, thereby reducing vibration.

13. Reversible crankshaft assembly permits direct connected engine drive.

14. Suction and discharge connections arranged for piping from either side of pump.

15. Skids optional for unitized portable mounting.

These sound construction features are the reasons why National Triplex Pumps perform at low cost on a host of pumping jobs. You can get complete information and fast delivery through the National Supply representative in your area.



This F-90 Triplex Pump is in use on a pressure maintenance project in Louisiana. The four triplex pumps (F-15, F-30, F-60 and F-90) in the National Line have a rated input hp range of 16.7 to 100 hp, with fluid ends available for high or low pressure, corrosive or non-corrosive service.

More National equipment for profitable production on the next page

Serial numbers are checked on these dual completion assemblies ready for shipment from National Supply's Houston Plant.

You get safe, profitable completions with National Dual String Wellhead Equipment!

All the basic benefits of field-proved National Wellhead Equipment are contained in National's dual string assemblies. Simplicity of design makes them easy to assemble and maintain. Parts are self-locating and self-activating. Interchangeable units provide a flexibility that enables you to "do more with fewer pieces." Every assembly is intensively pre-tested to insure complete safety.

National offers five types of dual string wellhead equipment designed for safe, profitable completions in a full range of working pressures. Included are such features as the time-proven Laurent* seal and an advanced automatic hanger design which eliminates the need for over-size preventers in "controlled completions."

Get the complete story on National dual string wellhead equipment today. National assemblies for *every* wellhead condition—as well as advisory service on applications—are readily available.

Get reliable service from precision-made National Sucker Rods. They have top resistance to fatigue, shock, corrosion and impulse loads. National Sucker Rods are available in a range of grades to meet every well condition.

National Pumping Units are manufactured in 22 standard combinations, plus various long stroke and portable variations. In the range of API rated beam loads from 3,200 to 32,400 lbs., there's a unit to economically meet your needs.

National Plunger Lift can be the best production method for certain types of wells. It uses formation gas or injected gas for operation, has low initial and service costs. Equipment is also available for gas well operation to remove liquids and maintain a uniform and increased flow rate of gas.

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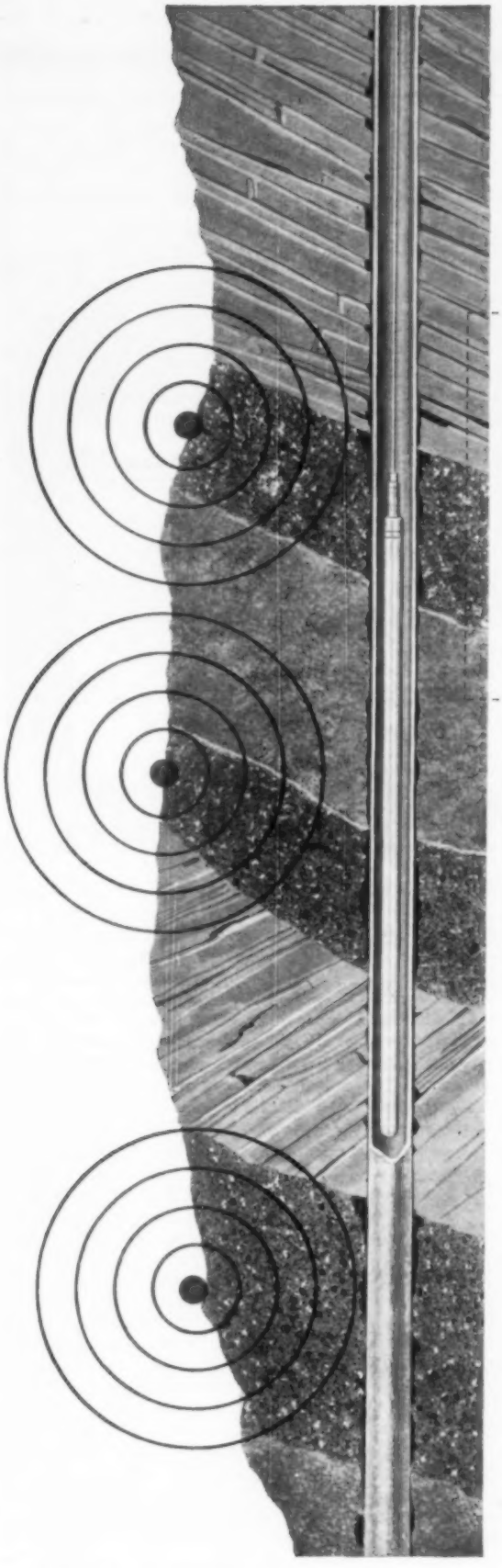
*Patent No. 2,687,229



Logging accuracy you can rely on...

THIN SANDS ACCURATELY LOCATED BY McCULLOUGH LOG FOR 400 B/D*

An electric log, run in this shallow Illinois oil well, proved of no value to the operator. Log curves were not detailed—thin sands were missed entirely.

McCullough's Radiation Well Logger was run, obtaining simultaneous Gamma Ray-Neutron Curves and a Collar Log. Thin sands were easily located from the detailed log. Correlation with core data was exact.

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U. S. Patents 2,686,266; 2,686,268; others pending.
Patented in Great Britain, Australia, Venezuela, Mexico, Brazil; others pending.

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**The job described above is certified to be a true field report of service rendered.*

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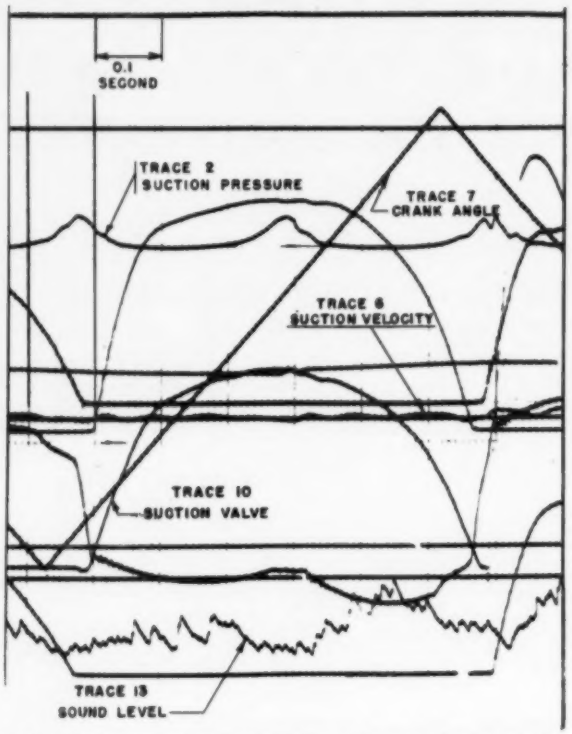

FIG. 2. **Under normal pump operation** with no fluid knock, this is type oscillograph recorded for 5½-in. by 14-in. duplex pump operating at 50 strokes per minute with a discharge pressure of 800 psi.

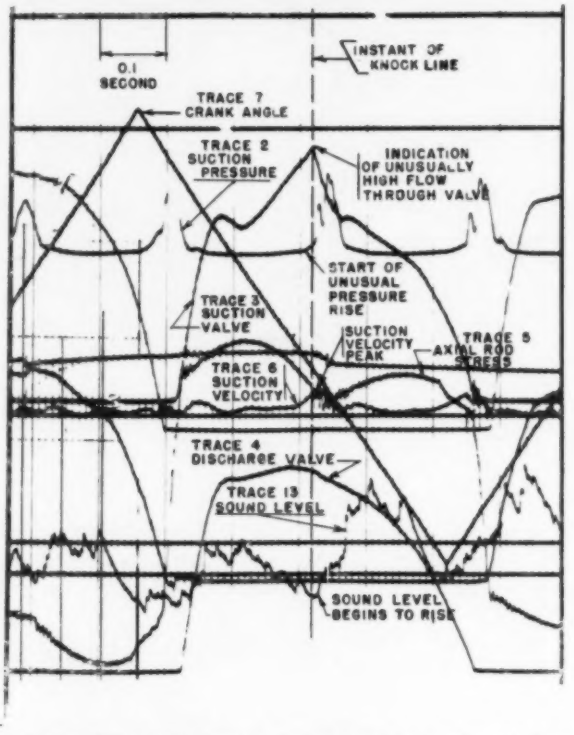

FIG. 3. **High fluid knock** is recorded on the oscillograph when 5½-in. by 14-in. duplex pump was speeded up to 65.9 strokes per minute and discharge pressure was 1500 psi.

the stroke when it is closing and might slam on the seat.

Data collected up to this point is somewhat confusing since it makes an incomplete story. In addition, volumetric efficiency tests gave high values during the hammering condition. The differences in test values were within the test error limit for tests with hammering in progress versus those with normal operation. This indicates that good cylinder filling was occurring.

Additional information was necessary to develop a complete picture of this behavior. A measurement of the velocity of the surge in suction pressure was necessary to determine if it was a water hammer type wave or one of a lower velocity. In addition, it was necessary to measure the instantaneous velocity in the suction to determine if the velocity departed from theoretical and if so, what actually took place.

How test conducted. In order to measure the pressure wave velocity, a group of strain gage bridges was installed on the suction pipe. The strain gages were used to measure hoop stress in the pipe, and outputs were calculated for the surge amplitudes that had previously been obtained. Amplification was required to obtain reasonable deflections of the galvanometers in the oscillograph.

The test was set in operation and five such bridges along the pipe plus the sound strip and suction pressure were recorded simultaneously. The oscillograph can be operated to feed 96 in. of photographic paper per second. This speed was used to increase the accuracy of velocity determination. The distance between strain gage bridges, along with the time when the different bridges were first strained, gave data to calculate velocity.

All bridges were spaced at unequal distances from each other because of construction reasons. This was fortunate since it helped prevent misinterpretation that might occur from resonant surge possibility with equal spacing. This test proved that the velocity was sonic and was somewhat slower in drilling mud than the 4000 ft per second velocity in water.

Measurement of Suction Flow Velocity

Examination of theoretical water hammer equations presented in many hydraulic texts, show that a pressure rise is directly proportional to the sudden reduction in flow velocity, therefore, the flow velocity should be measured.

Strain gages, in a special arrangement, were used to measure the normal suction velocity variation, and any deviation that may occur such as a sudden change of velocity. The velocity pickup consisted of a small drag disc which was supported by a thin rod with a flattened section at the root (see Fig. 5). Strain gages were attached on both sides of the root section of this cantilever beam. These were wired into a multiplying and compensating bridge which could be fed into the amplifier and recording oscillograph. A flexible epoxy material has been most satisfactory in water proofing the gages.

Calibration was accomplished by placing a supercharging centrifugal pump into the suction system so that a steady flow could be maintained and measured. A traverse was run across the suction pipe to obtain the velocity profile and to locate the average velocity point. The average velocity could then be compared to the velocity obtained in the volumetric test. The velocity probe was located at the average velocity point and impact tests were made on the probe to establish that its natural frequency was above the ex-

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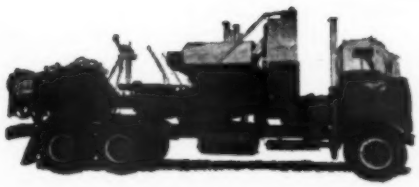
Components	Sand and non-thickened Hydrochloric Acid
Additives	Inhibitors, non-emulsifying chemicals, and fluid-loss agents
Method of Field Mixing	Continuous
API Fluid Loss	Generally less than 40 cc when ALC-5 is added
Where Best Suited	Any formation subject to acidizing

Sand-Acid has been developed to combine the advantages of fracturing and acidizing for more effective production stimulation in lime bearing formations. This service permits the use of Halliburton's non-emulsifying agents designed to prevent the occurrence of troublesome emulsions. Low fluid loss... the secret to more effective fracturing is accomplished with Halliburton's exclusive ALC-5 additive.

Field results prove the effectiveness of Halliburton's Sand-Acid. Records of the first six wells treated in a Mid-Continent area show improved production with no secondary emulsion problems. Numerous other cases may be cited where Sand-Acid has given similar results.

For more information about Sand-Acid, call your Halliburton Fracturing Engineer. Ask him for your free copy of the *new* bulletin, "Elements of Hydraulic Fracturing" which describes all Halliburton fracturing techniques.



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DUNCAN, OKLAHOMA

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pected velocity variation encountered under pulsating flow.

Results of these tests were very gratifying as is evident in the oscillograph records. In Trace 6, Fig. 3, shortly before the knock occurs, the velocity begins to rise and rises considerably above the velocity proportional to piston velocity. At the instant the knock occurs the velocity drops almost instantaneously to a lower velocity. At this time the velocity probe did vibrate, but the velocity up to the instant of knocking had been correctly recorded.

The calculated suction pressure rise, based on the sudden change of velocity from that measured by the probe down to piston velocity, is approximately that expected from the simple water hammer formula. This additional evidence completes the correlation between theory and test data.

Separation Described

Although the piston is at a standstill at the start of the stroke, its acceleration is very great. The mud, which is held back by its own inertia and by friction through the suction line and valve, does not have sufficient energy to equal this acceleration and falls behind. Thus, the piston velocity is greater than the fluid velocity in the cylinder at this time. By mid-stroke, the piston has been continuously increasing its velocity and sufficient force is not available to increase the acceleration of the mud enough to catch up to the piston. At mid-stroke, although the piston begins to slow down, the fluid continues speeding up because it is pouring into the evacuated space behind the piston; thus, its velocity continues to increase at a more rapid rate and it exceeds even the peak velocity of the piston.

Depending on all the variables, the fluid is likely to run into the piston some place in the second half stroke. At that instant the mud must reduce its velocity suddenly to that of the piston. Arresting the mud in such a short time causes water hammer and a high surge in pressure in the cylinder. This blow is the source of the sound that has been termed "hammer" and it occurs at the same instant as velocity reduction occurs. These findings complete the story of hydraulic knock as it occurs in an oilfield pump.

Other Sound Sources Checked

Additional insight into the problem has been gained by further tests and intensive study of a very large number of oscillograph records, as follows. Tests were run simultaneously on both sides of the duplex pump to insure that some other condition was not the source of the "hammer." Additional confirmation was obtained by operating only one side of the pump to obtain simplex operation data.

Trace 5, Fig. 3, representing the axial stress in the rod, always shows a sharp decrease in stress at the instant the knock occurs. The rod stress is decreased because the unusually high pressure on the suction side of the piston, balances a part of the even greater pressure load operating on the discharge side of the piston.

Referring again to Trace 3, Fig. 3, we find that the unusual valve motion curve also helps explain this phenomena. The valve is a crude flow indicator and its unusual motion curve follows the variations in velocity with a poor response to rapid change. Thus, the rise to the high peak, occurring at instant of knock, shows the increase in flow taking place into the cylinder. This means the valve merely reflects the flow pattern and has little influence on the flow.

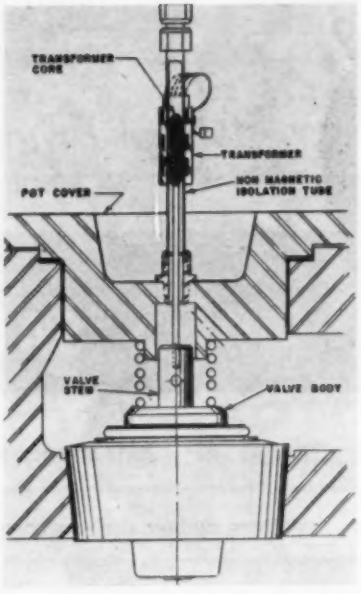

FIG. 4. **Valve motion pickup** was mounted in pot cover of all suction and discharge valves.

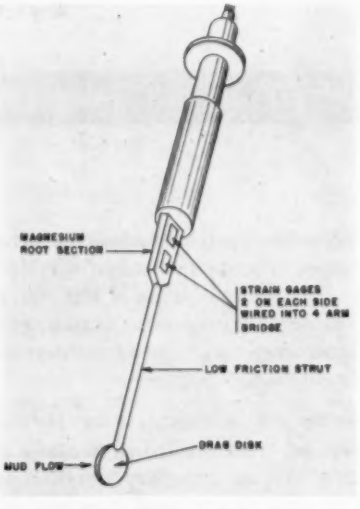

FIG. 5. **Mud velocity pickup** involved two strain gages mounted on a cantilever arm that recorded movement of the drag disc.

Present Solutions

In addition to slowing down the piston, which generally infers lower pump speeds, other less restricting methods of preventing this separation of the mud from the piston should be considered. Fluid knock may be prevented by such simple changes as reducing the length of suction line or increasing its diameter, both are to reduce friction losses. Increasing flooded suction level will also permit the pump to operate at higher speed before knock occurs. In addition, cool mud does not vaporize readily and a lower vacuum is available to accelerate mud into the cylinder.

When simple solutions such as the above are not possible, more complicated equipment may be required. A supercharging pump is a positive way of increasing the suction pressure enough to keep the cylinder full. Suction chambers may also be used to store and supply small amounts of liquid near the pump, as the surge in suction pressure demands it. The acceleration is so high at the start of the stroke that a suction chamber has great difficulties supplying the need and some surging results. However, separation is usually relieved much sooner than it is without the chamber and the impact is eliminated except occasionally at high pump speeds.

Additional Research Needed

Investigation continues of the actual impact forces that develop at the instant of hammer due to separation as is described above. There are many other causes for the various sounds that emanate from the fluid end of a pump of which separation is only one. A general check list of others in included in the appendix.

If there is a secret in understanding separation, it is that of the piston velocity which is the most relevant figure involved in its study. This particular study shows itself to be only a small part of many problems that occur in the fluid end of an oilfield mud pump. Continuous study of each of the details that enter into this problem should enable everyone to do a better job of efficiently operating this type pump. ★ ★ ★

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Double shut-in method is..

Newest Drillstem Testing Technique

and provides additional data, accuracy... speed of interpretation in formation evaluation

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3. True formation pressures.
4. Well productivities.

In exploration and development outpost wells, the drillstem test pressure chart is often the only pressure data available prior to completion. For this reason, the testing method known as the "double shut-in" is used by Mene Grande in Eastern Venezuela to utilize fully the information available from DST pressure charts. Fig. 1 outlines the drillstem procedure and equipment to use the double shut-in method.

In recent years, increased interest in the value of DST chart interpretation has resulted in development of pressure recording gages which are highly accurate. Widespread sub-surface pressure control in fields under active development has proved the error of these gages to be less than one percent in the ranges above 1500 psig.

An average well in Eastern Venezuela may have up to 20 potentially productive sands and prior to completion several sands may be tested for reservoir information only. In view of the large amount of money spent for formation testing, the relatively small additional shut-in time and effort expended on DST chart interpretation is justified to obtain full value from each test. This article presents a fast and accurate method for interpretation of DST charts. These methods represent a composite of those outlined in articles appearing in recent publications,[1,2] which extended and modified the well-known pressure build-up analysis methods.

Theory

Certain assumptions have been made about the properties of the fluid and

Presented as "Application of Drill Stem Test Data to Formation Evaluation in Eastern Venezuela" at the November 6, 1957 AIME meeting in Caracas, Venezuela.

How to Calculate Position of Disc Sub

In order to properly locate the position to insert the disc sub, it is necessary to make a calculation as follows:

Example:

Casing size	5½ in.—17 lb per ft
Total depth	4552 ft
Packer depth	4370 ft

Calculate the volume of the hole below the packer, which in this example, is 182 ft. Refer to your capacity tables and find 5½ in.—17 lb csg. which shows .0232 bbl per lin ft which gives .0232 × 182 ft = 4.22.

In order to release compressed fluid (pressure hydrostatic mud weight) which will be trapped below the tester valve and the packer just prior to the opening of the tool, it is necessary to allow between the tester valve and the disc sub, **not less than 10 percent** and **not more than 15 percent** of the calculated volume. Therefore, 10 percent of 4.22 bbl = .42 bbl. Assuming that the testing string of tubing is 2½ in. API 6.4 lb, which has a capacity of 173 ft per bbl, the disc sub by calculation should be located 173 ft × .42 bbl or not less than 73 ft above the tester. Since this is longer than 2 joints it would be necessary to run 3 joints of tubing between tester and disc sub.

In the event a water cushion is used, the air chamber is left between the top of the water cushion and the disc valve. If a substantial amount of cushion is to be used, the expansion of water due to temperature must be calculated.

Example: (same as above with 1000 ft of water cushion)

Water cushion = 1000 or approximately 5.8 bbl in 2½ in. tubing
Bottom hole temperature = 200F
Cushion expansion = 5.8 × .04 = 0.23 bbl
Cushion expansion in 2½ in. tubing = 0.23 × 173 ft per bbl = 40 ft
Cushion expansion plus air chamber = 40 plus 73 = 113 ft correct air chamber

Several precautions that will help prevent trouble and increase the accuracy of the results are worthy of mention. To insure accurate pressure recordings, recalibrate pressure elements and service clocks frequently. Obtain accurate mud weights. Design the test procedure to fit the formation, when this information is known.

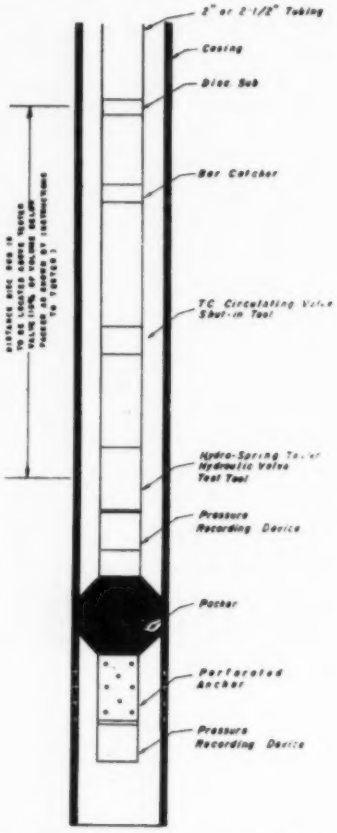

FIG. 1. Drillstem test procedure and equipment arrangement for "double shut-in" method of formation testing.

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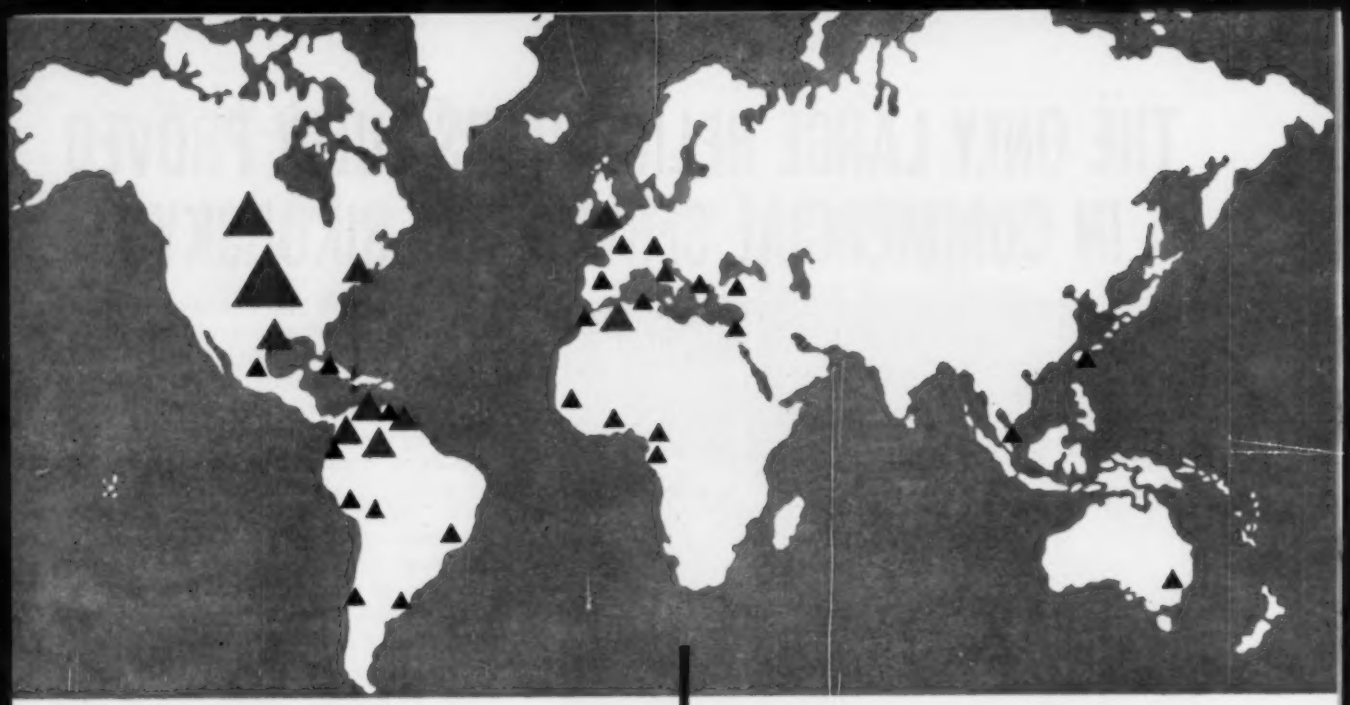

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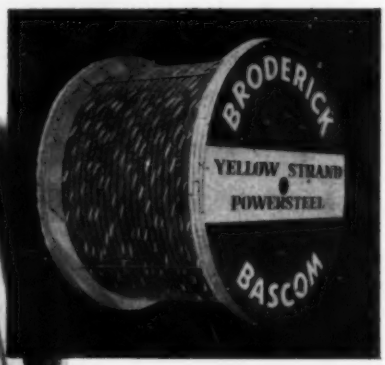

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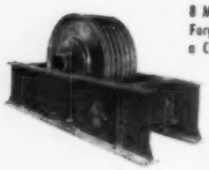

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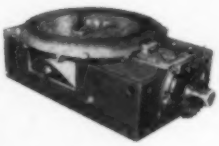

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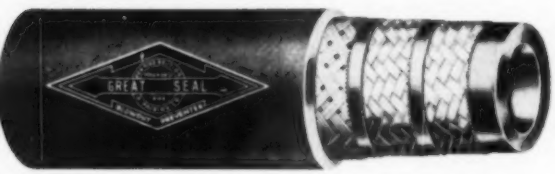

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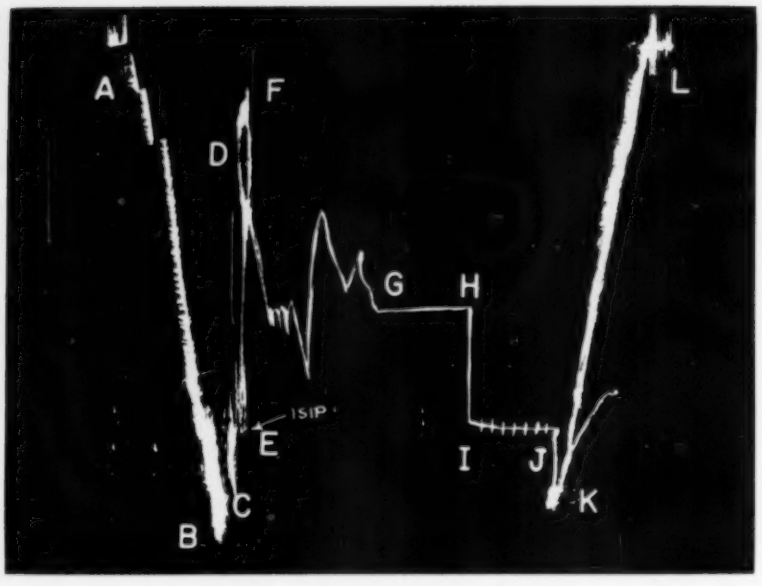

T2 SAND
ZM-310

A-B	**Going in hole with tester**
B-C	**Initial hydrostatic mud pressure, seated packer**
C-D	**Opened hydrospring tester**
D-E	**Initial closed-in pressure**
E-F	**Broke disc sub for open flow test**
F-G	**Swabbing and initial flow period**
G-H	**Stabilized flow on test**
H-I	**Closed TC circulating valve**
I-J	**Final closed-in pressure build-up**
J-K	**Final hydrostatic mud pressure, unseated packer**
K-L	**Pulled out of hole**

FIG. 2. **Drillstem test chart** indicating steps in the DST.

character of the reservoir:

1. Reservoir is infinite in size.
2. Flow into the wellbore is radial.
3. Reservoir fluid is a single-phase liquid of low but constant compressibility.
4. Permeability, porosity and net thickness of formation are sufficiently uniform to be expressed as average effective values.

Horner[3] has pointed out that practical applications of pressure build-up curves in a normal well, indicate it may produce for some time and still obey the "infinite reservoir" theory. Because of the shorter flowing time in drillstem testing, the assumptions and concept of infinite radius are more realistic than in conventional flow and build-up tests on producing wells.

The point-sink solution,[3] for the equation of flow,[4] expressed in usual field unit is the basis for the determination of pressure, permeability, and damage effect used in this paper:

$$Po - Pw = 162.6 \frac{qu}{kh} \log \frac{t + e}{e} \quad (1)$$

Nomenclature

Symbol	Description
DR	damage ratio — dimensionless
h	sand thickness — ft
K	permeability — md
Kh/u	transmissibility — ft/cp
PI	productivity index — BPD/psi
Pf	flowing pressure — psi
Po	pressure at infinite bounday — psi
Ps	extrapolated formation pressure — psi
Pw	pressure at well bore — psi
P	pressure difference over one logarithmic cycle — psi/cycle
q	varying production rate — BPD
qa	average production rate — BPD
t	flowing time — minutes
u	viscosity — cp
e	shut-in time — minutes

DRILL STEM TEST DATA FORM

TX. #TV-10358

Field Zapatos Well No. 310 Date October 2, 1957
Formation Tested T2 Perf. Interval 12358-66 Test No.
Testing Tool HS-HWP-TC-2BT "BT" PRD No. 833 Depth 12295
Total Depth RTE 24 Hr. Clock No. 4316
Packer Depth 12290 Size and Type 5-1/2 J-20
Disc Sub Depth 9590 Tubing Size and Wt. 2" N-80
Size and Length Anchor

MUD DATA
Type Salt Water
Weight 9.6 Lbs/gal.
Viscosity Sec.
Filter Loss cc Cake in.

Witnessed by Calloway

Data Chart Prepared by Arbuthnot Bottom Hole Temp. 250 °F

*A	TIME	PSIG
Initial Hydro Mud Pressure		2.110-6085
Initial Closed In Pressure		1.885-5424
Initial Flow	8:50 AM	.175- 515
Final Flow	7:30 PM	1.230-3535
Final Closed In Pressure	11:00 PM	1.815-5220
Final Hydro Mud Pressure	11:00 PM	2.105-6065

Remarks: Opened Tool 8:50 A. M. Opened Disc Sub 9:20 A. M.
Closed TC Valve 7:30 P. M. Pulled Tool off 11:30 P. M.
Rate 117 BOPD 1/4" Choke 400# THP 880 GOR 29.0 Gvty. 0.1 Cut
4 hour test.

*B. INITIAL CIP Time Defl. .000"	Psi Defl. .000"	Psi Temp Corr.	FLOW PRESSURE Time Defl. .000"	Psi Defl. .000"	Psi Temp Corr.	FINAL CIP Time Defl. .000"	Psi Defl. .000"	Psi Temp Corr.
			8:50 AM	.175	515			
				1.245	3575	30 mins	1.785	5160
				1.285	3695	60 mins	1.795	5175
				.790	2270	90 mins	1.800	5180
15	1.820	5225		1.070	3065	120 mins	1.805	5190
30	1.820	5225		1.230	3535	150 mins	1.810	5192
				1.230	3535	180 mins	1.815	5195
				1.230	3535	210 mins	1.818	5200
				1.230	3535			
				1.230	3535			

15 minute intervals 2 hr. minute intervals 30

*Sections A and B are to be completed by Service Company.

FIG. 3. **Data form** to record information from the DST chart.

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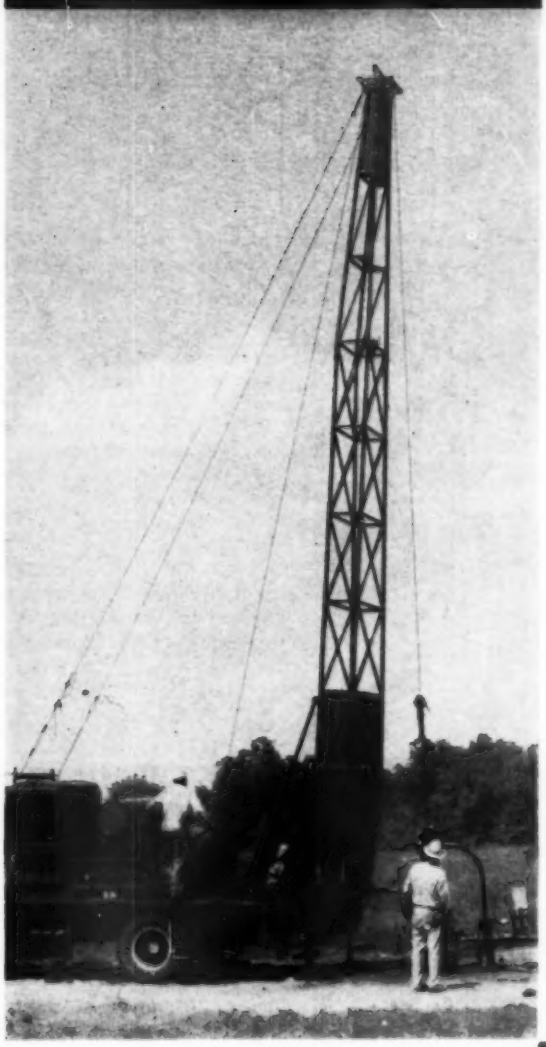

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Analysis Methods

A TRUE OR ORIGINAL FORMATION PRESSURE can usually be determined from drillstem charts prior to completion. In extrapolating the final shut-in pressure build-up curve to obtain the true formation pressure, certain errors are possible due to insufficient shut-in time, low capacity formations, and heterogeneous reservoir characteristics and fluid properties where certain basic assumptions were made. This pressure can be found by extrapolating the final shut-in pressure build-up curve when a plot of log t + e ÷ e vs Pw on semi-logarithmic paper is made. Note that these factors appear in Equation 1.

Experience in plotting a large number of DST charts has shown that a straight line is usually obtained. Accurate extrapolation is most difficult when a large pressure difference remains between true formation pressure and final shut-in pressure at the end of the test.

The double shut-in DST technique minimizes inaccuracies in extrapolation to true bottom-hole pressure (BHP) since initial shut-in pressure represents true or original formation of pressure. This is in accordance with the basic theory of the double shut-in DST and is due to the fact that a negligible drawdown of the reservoir occurs during initial shut-in pressure measurement. Therefore, it is not subject to adverse factors that affect final shut-in pressure build-up curves such as skin effect or damage ratio, low permeabilities, faults, etc.

DST DATA COMPILATION FORM

Well No. ZM-310 Sand T2 Date October 2, 1957

CHART DATA

Time, t	e	t / e	$\frac{t / e}{e}$	P, psi
Initial Closed-In Pressure Build-Up Data				
60	15	75	5	5225
60	30	90	3	5225
Final Closed-In Pressure Build-Up Data				
610	30	640	21.3	5160
610	60	670	11.2	5175
610	90	700	7.8	5180
610	120	730	6.1	5190
610	150	760	5.1	5192
610	180	790	4.4	5195
610	210	820	3.9	5200
Initial closed-in time - 30 minutes				
Open flow time - 10 hours and 10 minutes				
Final closed-in time - 3 hours and 30 minutes				

Where: t = open flow period in minutes

e = closed-in time in minutes

P = closed-in pressure corresponding to closed-in time e.

FIG. 4. **Drillstem test data compilation form** used to calculate the points for pressure build-up curves.

Transmissibility or Permeability

A pressure curve cannot measure permeability as such. The factor measured is called transmissibility, Kh/u. To determine this factor the following formula is used and is derived from Equation 1:[1,2,3,5]

$$\frac{kh}{u} = 162.6\,\frac{qa}{P} \quad . \quad . \quad (2)$$

To reduce transmissibility factor to effective permeability requires an accurate knowledge of net effective sand thickness and effective fluid viscosity. This method of calculating average effective permeability measures the transmissibility factor of the entire drainage area and may represent a more accurate value than the permeability reconstructed from isolated core plugs from the section.

Productivity Index

The conventional productivity index measured is a function of formation permeability, fluid viscosity, wellbore damage, valve restriction and many other factors. PI is calculated by using:

$$PI = \frac{qa}{Ps - Pf} \quad . \quad . \quad (3)$$

The necessary pressure points, flowing pressure (Pf) and true formation pressure (Ps), in addition to the flow period in minutes are obtained from the DST chart. The amount of fluid recovery per unit time (qa) is either reported as such in the case of a flowing test or is calculated by knowing the amount of fluid recovered in the pipe per unit time.

Damage Ratio

As described by Dolan[2] and others, two values of productivity index are obtainable from the DST chart. The first productivity index value has been described above. The second value comes from an analysis of the final shut-in curve. Where the first value of productivity index is affected by wellbore damage, the second value is nearly independent of damage since essentially no flow occurs during final shut-in time.

Damage ratio may be easily calculated by using:[2]

$$DR = 0.183\,\frac{Ps - Pf}{P} \quad . \quad (4)$$

The following equation, which is used in this article to calculate ratio is another form of Equation 4:

$$DR = \frac{Kh}{u} \times \frac{0.00113}{PI} \quad . \quad (5)$$

Damage ratio defined here is an empirical factor intended for practical immediate evaluation and should not be considered as a precise determina-

THE AUTHOR

Charles D. Hatfield *is a reservior engineer with Mene Grande Oil Company San Tomé, Venezuela. Receiving a BS degree in petroleum engineering from the University of Tulsa in 1952, he was employed by Gulf Oil Corporation until 1956. Before being transferred to Venezuela, he worked in Gulf's Research and Development Laboratory at Harmerville, Pennsylvania, and in the Wichita, Kansas, zone office as reserve and development engineer.*

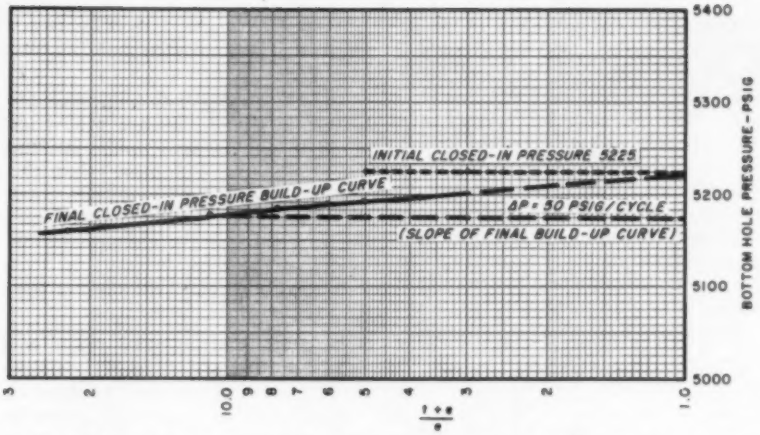

FIG. 5. **Semi-log plot** of initital and final pressure build-up curves to determine true bottom-hole pressure.

tion. Although more precise methods are described in the literature,[5] this damage ratio equation is used in the conventional analysis of DST charts.

Theoretically, a formation with a damage ratio of 5 should produce at a rate 5 times greater than that recovered under damaged conditions. In practice, however, maximum potential is seldom fully restored after well bore damage occurs due to treating difficulties, such as low injection rates, high pressures and poor cement sheaths.

Results

In general, damage to the wellbore, or damage ratios, may be classified as: High, medium, low in zones of good permeability, and low in zones of poor permeability. Damage is considered negligible in zones having a damage ratio of less than 1. Some well conditions can be detected by quick visual inspection of the chart. For example, wellbore damage is always suspected when there is a decrease in flowing BHP and a rapid build-up in final shut-in pressure.

A step by step procedure of calculation follows for a well showing a high damage ratio from drillstem test data. This same procedure is used to analyze all charts, regardless of the well condition found.

The T2 sand was perforated 12,358-66 ft and during a double shut-in DST, produced at the rate of 117 bbl of oil per day on ¼-in. choke with 400 lb of wellhead pressure. A damage ratio of 7 was calculated which indicated a potential flow rate of 820 bbl of oil per day under non-damaged conditions. The reservoir engineer recommended an oil squeeze to remove the wellbore damage. After several failures due to mechanical difficulties down-the-hole, a satisfactory oil squeeze was performed, however, the results were considered inconclusive, and the sand was squeezed and another sand perforated for completion. Exact procedure, calculations and results are:

Step 1. Fig. 2 shows a copy of the drillstem test chart and a brief outline of the testing procedure. It is of interest to note that the rapid final shut-in pressure build-up is often indicative of wells with good effective permeability and high wellbore damage.

Step 2. Fig. 3 is the Drill Stem Test Data Form which was prepared by the service company and is believed to be self-explanatory. DST pressure measurements appear in the lower section of the data form.

Step 3. Fig. 4 is the "DST Data Compilation Form" prepared from data shown on Fig. 3. An open flow time of 610 min plus the shut-in time in 30-min intervals is tabulated with the corresponding final shut-in pressure build-up points. An initial shut-in pressure of 5225 psi was measured and represents true reservoir pressure.

Step 4. Fig. 5 is a semi-logarithmic plot of the initial and final shut-in pressure build-up curves. As the value log $t + e \div e$ approaches 1, infinite shut-in time is approached and the true reservoir pressure is reached. In practice final shut-in periods equal to one-half the open flow periods are used. When-

DST ANALYSIS FORM

Field Zapatos Well No. ZM-310 Date October 3, 1957

Sand T2 Sand Thickness 5' Perf. Interval 12375 - 12383

Gauge Depth 12295 RTE 699 Subsea 11,596 Mud Weight 9.6 lbs/gal (Salt Water)

Time: open t_f 610 (total mins) closed-in: initial e, 30 Final, e 210 mins.

Recovery:	Rate	Choke	GOR	WHP	Gvty.	Cut	Test Period
	117 BPPD	1/4	880	400	29.0	0.1	4 hours

Mud Pressure:

1. Hydro-Mud pressures: Initial, Phsi = 6085 psi; Final, Phsf = 6065 psi; ΔPhs 20 psi
2. Gauge Depth (12295) x (mud wt.)(9.6)lb/gal. x .052 = Phs (calc.) 6145 psi
3. Phs (calc.)(6145) ÷ Phsi (6085) x 100 = 101 %

Average Production Rate:

A. DST recovery calculated in Bbls. (QT)
4. qt = 1440 min. x Qt ( ) bbls t_f ( ) mins = 117 B/D

B. DST flowing rate on test to station (Qs)
5. Qs = qt (117) bbls. x F.V.F. (1.73) = 202 B/D

Transmissibility:

6. $\left(\frac{Kh}{u}\right)$ = 162.6 x Qs (202) ÷ ΔP (50)psi/cycle = 657 md-ft/cp.
7. Specific, K/u = 6 (657) ÷ h (5) ft. = 131 md/cp.
8. Estimated average permeability 7 (131) x (est.)(0.9) cp. = 118 md.

Productivity Index: (Fluids only) (5225 - 3535)

9. $(P.I.)_T$ = qt (117) ÷ $(P_s - P_f)$(1690) = 0.07 B/D psi
10. Specific$(P.I.)_T$ = 9 (.07) ÷ h (5)ft= 0.014 B/D psi ft.

Damage Ratio:

11. D.R. = $\left(\frac{Kh}{u}\right)$(657) x (.00113) ÷ $(P.I.)_T$ (.07) = 10

Bottom Hole Pressures:

12. Extrapolated BHP from Initial closed-in pressure curve-- 5225 psi
13. Extrapolated BHP from Final closed-in pressure curve---- 5225 psi

FIG. 6. **Drillstem test analysis form** used to collect data and calculate permeability, productivity index and the damage ratio (extent of formation damage).

ever double shut-in DST's are run, shorter final shut-in periods are permissible. The extrapolated final shut-in pressure and initial shut-in pressure are shown as 5225 psig. Slope of the final build-up curve equals 50 psig per cycle.

Step 5. Fig. 6 shows a summary data sheet called DST Analysis Form. Main purpose of this form is to summarize all DST data and calculate transmissibility or permeability, productivity index, damage ratio and accuracy of the pressure recording device.

Step 6. The top portion of the form shows routine DST and well information. Under parts 1, 2, and 3 of Mud Pressure section, a ratio expressed in percent of the calculated hydrostatic mud pressure to measured mud pressure is shown, thereby checking accuracy of the pressure recording device. If this ratio exceeds 102 percent or is less than 98 percent, accuracy of the pressure recorded is questionable or the reported mud weight in error. For the T2 sand DST, a ratio of 101 percent was calculated which is acceptable.

Step 7. Average production rate is calculated in stock tank and reservoir volumes.

Step 8. To calculate transmissibility shown in Fig. 6, average production rate and slope of final shut-in pressure curve are used. With these values plus the net sand and effective fluid viscosity, the transmissibility factor was reduced to an average effective permeability of 118 millidarcys.

Step 9. A productivity ratio of 0.07 was calculated for the T2 sand.

Step 10. A damage ratio of 10 was calculated from the more complete DST data. Damage ratio calculated at the well site was 7; however, it must be remembered that pressures read from DST charts at the well site are not as accurate as those pressures read under more favorable conditions and accounts for the difference between damage ratio of 7 and 10.

Conclusions

The double shut-in method not only eliminates many possible errors in pressure build-up analysis, but together with other drillstem test data normally obtained will provide important information:

1. A true formation pressure.
2. The effective permeability of a formation may be calculated quickly, at the well site, by using the empirical equation and simplified methods outlined.
3. Well bore damage can be immediately determined at the well site to permit a better well completion. A damaged zone can normally be expected to produce a greater amount of fluid, after successful treatment, that will be approximately equal to the damage ratio times the volume recovered.

Acknowledgment

The author wishes to express his appreciation to Mene Grande Oil Company for permission to prepare this paper.

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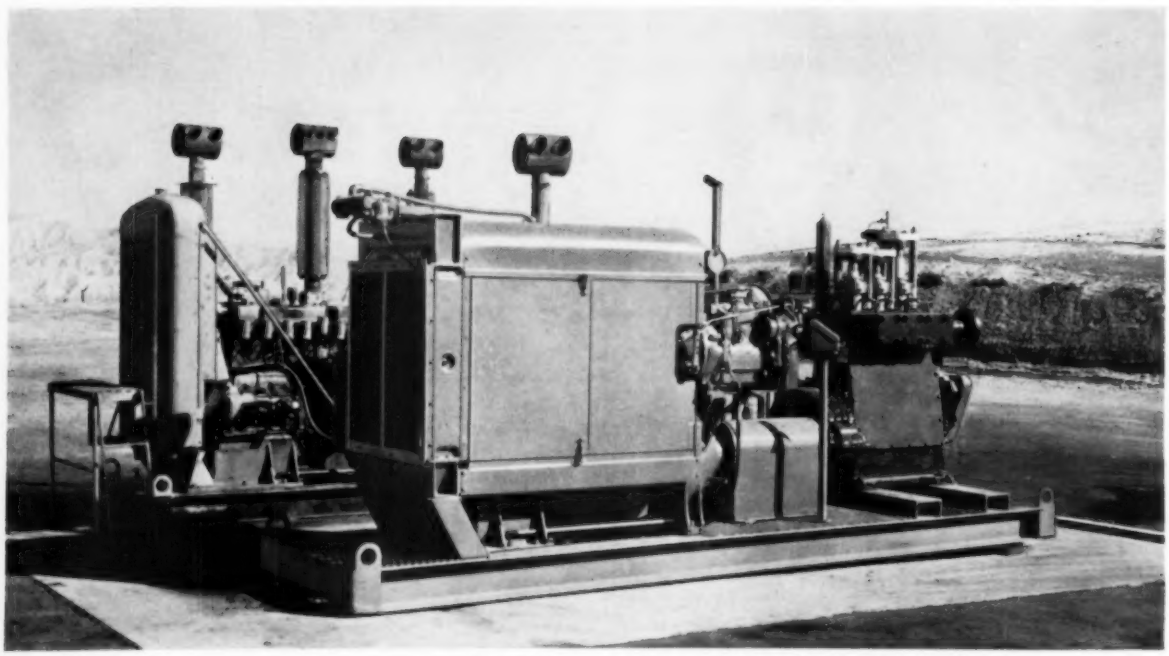

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The National Supply Company, Houston, Texas

THE POWER used to pump mud on drilling rigs is increasing steadily. The 500 to 1000-hp mud systems put in service a decade ago are being replaced by 1500 to 2000-hp systems. Even more powerful systems will probably be used in the future.

Much of this power is being added to increase the hydraulic power at the bottom of the hole. Jet bits have proved that penetration rates can be increased substantially by high down-hole power. It now appears that other down-hole mud-operated devices such as reciprocating motors, turbines, or positive displacement rotating motors will be advantageous. These devices will further increase the hydraulic power used at the bottom of the drill string.

These developments make it important to examine the means by which hydraulic power is supplied to mud operated devices on the bottom of the drill string.

Hydraulic Power at the Bottom of the Drill String

Amount of hydraulic power at the bottom of the drill string depends on both the mud system and the down-hole device which the mud operates. To get the highest down-hole hydraulic power two conditions must be met. First, mud system losses must be reduced as much as possible. Second, the down-hole device must be matched to the rest of the system.

Mud system losses are reduced by using tubular material with the largest possible bore and by using the lightest mud which hole conditions permit. Surface mud pressure should be the highest which can be maintained economically, as pressure contributes to the power but not to the mud system losses.

The down-hole mud-operated device matches the rest of the system when it has the right pressure drop at an optimum mud flow rate. There is a considerable difference in the pressure drop of different devices. An open bit has practically no pressure drop even at very high mud flow rates. A jet bit with very small nozzles can have such a high-pressure drop that the maximum economic mud pressure is reached at a very low mud flow rate. The pressure drop and mud flow rate for the highest down-hole hydraulic power are between these extremes.

Best Pressure Drop at Bottom of Drill String

Pressure drop across the bit or other device on the bottom of the drill string has a considerable effect on the down-hole hydraulic power. An example illustrates this.

In West Texas, a rig could be found drilling 8¾-in. hole at 10,000 ft using jet bits. Maximum economic mud pressure might be 2500 psi. Effects of changing the mud flow rate, while keeping 2500 psi mud pressure by changing the bit nozzle sizes, are shown in Fig. 1. When the mud flow rate is increased, the pump power always increases. Hydraulic power at the bit first increases with increased flow rate, then decreases. Maximum hydraulic power at the bit occurs when the pressure drop across the bit is about two-thirds of the maximum economic mud pressure.

Conclusions reached from this are: (1) With any given hole dimensions, mud weight, drill string, and mud pressure limitation, there is a maximum hydraulic power which can be achieved at the bottom of the drill string, and (2) To get maximum hydraulic power, the device on the bottom of the drill string must be designed to operate with a mud flow rate and a pressure drop dictated by the rest of the system. Pressure drop must be about two-thirds of the maximum economic mud pressure.

Best Mud Flow Rate

The mud flow rate which produces maximum hydraulic power at bottom of the drill string varies with dimensions of the drill string and hole, weight of mud, and maximum economic mud pressure. It is given by the approximate equation:

$$Q_{opt} \approx \left[\frac{P_{limit}}{2.9\,K_1}\right]^{0.53} \cdot \quad (1A)$$

Where

Q_{opt} = Best mud flow rate in gal per min.

P_{limit} = Maximum economic mud pressure in psi.

K_1 = A function of hole and pipe dimensions, and mud weight.

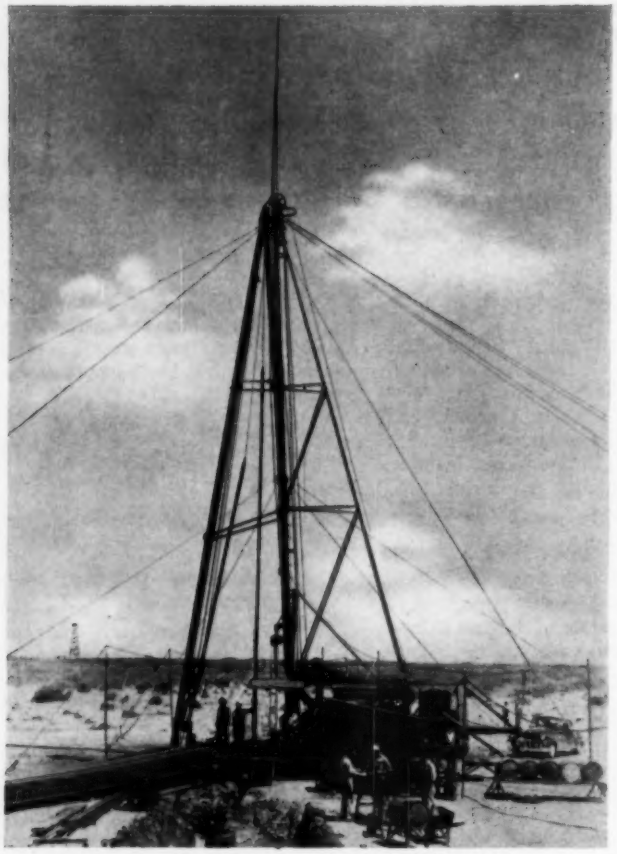
Derivation of this expression is in the appendix.

Mud flow rates for maximum hydraulic power at the bottom of the drill string for three example holes are shown by Fig. 2. The significant thing is that there is a great difference in the best mud flow rate for different types of holes. The best mud flow rate for a slim hole may be as little as one-fourth of the best mud flow rate for a South Louisiana hole at the same depth using the same mud pressure.

The graph also shows that the best mud flow rate is much greater for shallow holes than for deep holes. In the South Louisiana example hole the best mud flow rate at 2000 ft is almost twice the best mud flow rate at 12,000 ft with the same surface mud pressure.

High pump power is required at shallow depths because of the high mud flow rate. At less than some certain depth, pump power called for will be greater than the pump power available. At less than this depth the down-hole hydraulic power is limited by the pump power rather than by the factors involved in Equation 1A. In practice this has little net effect. The actual down-hole hydraulic power is high at shallow depth and this portion of the hole is usually finished in the first few days of drilling.

Faulty Replacement Parts Cost Contractors Thousands of Dollars Annually in Downtime



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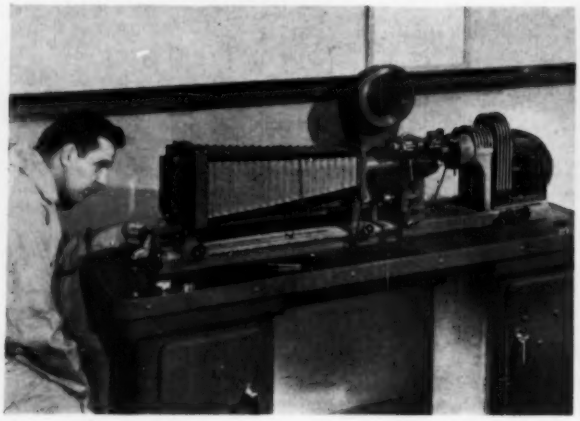

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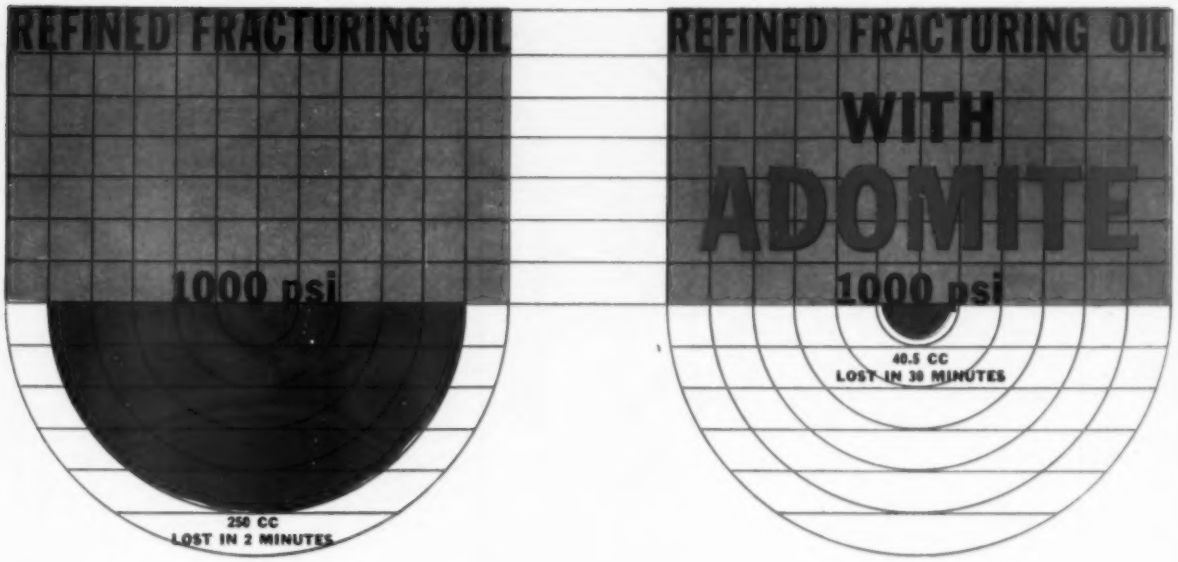

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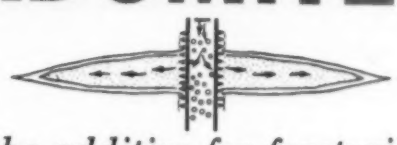

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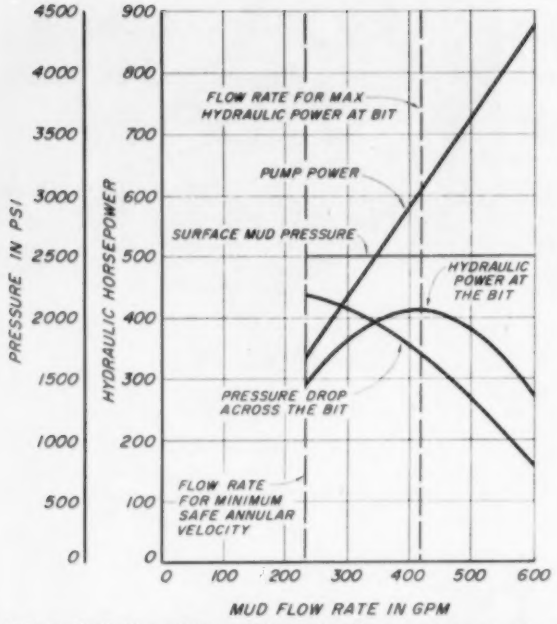
PRESSURE IN PSI
HYDRAULIC HORSEPOWER
MUD FLOW RATE IN GPM
FLOW RATE FOR MAX HYDRAULIC POWER AT BIT
PUMP POWER
SURFACE MUD PRESSURE
HYDRAULIC POWER AT THE BIT
PRESSURE DROP ACROSS THE BIT
FLOW RATE FOR MINIMUM SAFE ANNULAR VELOCITY

FIG. 1. **Variation of down-hole hydraulic power,** pump power and pressure drop across the bit with mud flow rate for an 8¾-in. West Texas type hole at 10,000 ft.

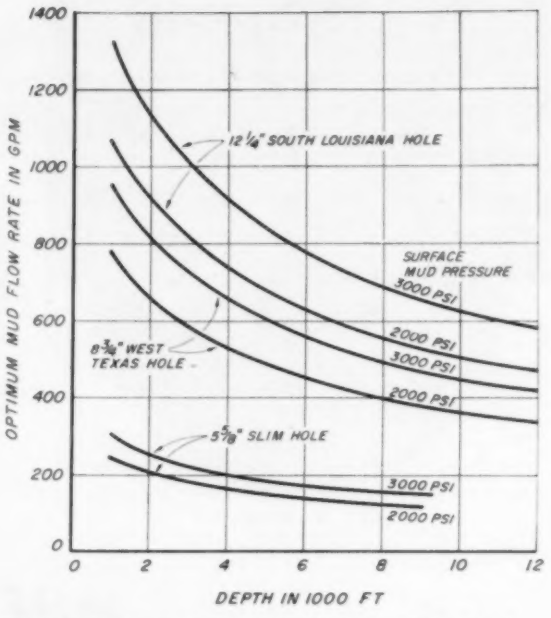

FIG. 2. **Variation of optimum mud flow rate** with depth and surface mud pressure for three example holes.

Work* presented several years ago indicates that when the device on the bottom of the drill string is a jet nozzle, drilling rate is greatest when product of flow rate times nozzle velocity is largest. This product represents the impact of the mud stream on the bottom of the hole. Impact is made greatest with slightly different conditions than those for maximum down-hole hydraulic power, but the differences are not large. Maximizing down-hole hydraulic power will result in an impact about five percent less than the maximum possible impact under the same conditions. General conclusions reached concerning a system for maximum down-hole hydraulic power are also applicable to systems in which impact is maximized.

Power Transmission Efficiency

Efficiency with which hydraulic power is transmitted to a down-hole mud operated device is equal to the ratio of the pressure drop across the device to the surface mud pressure.

Down-hole hydraulic power is highest when this ratio is about 0.66; with any given hole, drill string, mud weight, and surface mud pressure. Efficiency at maximum down-hole hydraulic power is, therefore, about 66 percent. The efficiency can be made higher only if less power is acceptable.

To make the efficiency higher it is necessary to use a lower mud flow rate and a down-hole device with greater mud flow resistance. The limiting case occurs when the down-hole device will pass no mud at all. Efficiency is 100 percent but the power is zero.

Less than 66 percent efficiency, as well as reduced down-hole power, result when the pressure drop across the down-hole device is less than 66 percent of the surface mud pressure.

Mud-Powered Devices

On any given rig, the best pressure drop across the device on the bottom of the drill string is likely to be constant for intervals of several thousand feet of drilling. The best pressure drop is constant because it is a fixed portion of the maximum economic mud pressure which in turn is determined by the pressure rating and maintenance costs of the mud pumps and associated equipment. Changes are not likely except when the pump liner size is changed.

Optimum mud flow rate varies considerably. It is affected by changes in hole depth, mud weight, and drill string bore as well as maximum economic mud pressure.

Therefore, it is desirable for a down-hole mud operated device to be designed for a pressure drop which is essentially constant, and for a mud flow rate which varies considerably.

Table 1 shows how well jet bits can conform to this ideal. The tabulation shows jet bit nozzle sizes and mud pump power needed to get maximum hydraulic power at the bottom of the drill string while drilling the 12¼-in. diameter portion of a South Louisiana type well with 3000 psi mud pressure. Nozzle sizes required vary from 5/8 in. to 13/32 in., depending on depth and number of nozzles. Pump power required varies from 1600 hydraulic hp at 4000 ft to 1000 hydraulic hp at 12,000 ft.

It is significant that these values, calculated for maximum down-hole hydraulic power, are very close to those actually used in the most advanced current jet drilling practice. This indicates that the most advanced current jet drilling practice is very close to the ideal. The down-hole hydraulic power is nearly the highest possible with the pipe sizes, mud weights, and surface mud pressures now considered economic. No further significant increases can be made in hydraulic power or impact at the bottom of the hole without using larger bore drill strings, lighter muds, or higher surface mud pressures.

Devices other than jet bits can use hydraulic power at the bottom of the drill string. There are reciprocating motors, turbines, positive displacement rotating motors, and other devices. To the greatest extent possible, these devices should be arranged to conform to conditions for maximum down-hole power. Deviations from these conditions, particularly in the direction of reduced pressure drop, have considerable effect on surface mud pressure and pump power required.

Low Pressure-Drop Mud-Operated Devices

Conditions necessary to get the lowest possible surface mud pressure with

*"The Relation of Nozzle Fluid Velocity to Rate of Penetration of Drag-Type Rotary Bits," J. P. Nolley, G. E. Cannon, and Douglas Ragland. API Drilling and Production Practices, 1948.

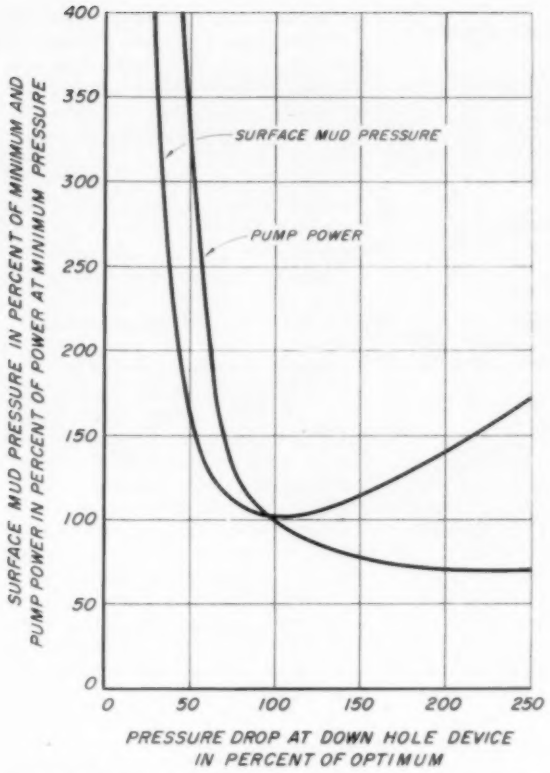

FIG. 3. **Variation of surface mud pressure** and pump power with pressure drop across the down-hole device for constant down-hole hydraulic power.

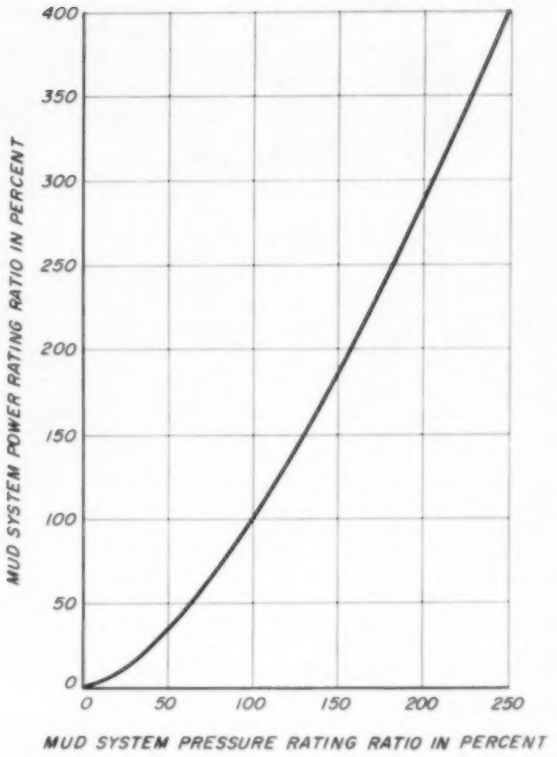

FIG. 4. **Variation of mud system** power rating with pressure rating for maximum down-hole hydraulic power.

any given down-hole power are described by mathematical expressions identical to those derived in the appendix for maximum down-hole power. This means that a pressure drop across the device on the bottom of the drill string of about two-thirds of the surface mud pressure will produce the lowest possible surface mud pressure with the down-hole power realized.

Fig. 3 is a graph showing the surface mud pressure and pump power needed to operate down-hole devices of the same power, using the same drill string and mud weight, but with different pressure drops. As an example, compare the surface pressure and pump power needed when using an optimum device to surface pressure and pump power needed when using a device with one-half the pressure drop and twice the flow rate of the optimum device. The graph indicates that a device with one-half the optimum pressure drop requires a surface mud pressure about 160 percent of that needed for an optimum device. Pump power is 320 percent of pump power needed for an optimum device.

It is, therefore, very desirable for a mud operated down-hole device to be designed for a pressure drop and a mud flow rate as close as possible to the optimum.

Future Pump Requirements

Higher powered jets may be used in future jet drilling. This will increase the required pressure and power ratings of future mud systems. The pressure and power ratings needed can be anticipated from the relation of pump power to surface mud pressure for optimum flow rates. This relation is expressed mathematically by Equation 3A.

$$HHP \approx \frac{(P_{limit})^{1.53}}{K_2(2.9\,K_1)^{0.53}} \quad . \quad . \quad . \quad (3A)$$

Where

HHP = Hydraulic hp of the pump.
P_{limit} = Maximum economic mud pressure in psi.
K_1 = A function of hole and pipe dimensions, and mud weight.
K_2 = A constant relating pressure and flow rate to hydraulic hp.

Derivation of this expression is in the appendix.

This equation indicates that under these conditions the power rating of a mud system should vary as the 1.53 power of the pressure rating. Fig. 4 is a graph showing how the pump power changes as the pressure rating is changed. It is plotted in terms of the ratio of power ratings which accompany a ratio of pressure ratings.

As an example consider the effect if the mud pressure is increased to 5000 psi in a system now using 3000 psi. This is an increase in pressure rating to 167 percent. Corresponding pump power increase is to about 220 percent.

Table 2 shows the effects of this in-

TABLE 1. Sample Data for Maximum Down-Hole Hydraulic Power in a 12¼-in. South Louisiana Type Hole.
Maximum economic mud pressure is assumed to be 3000 psi

Depth: ft	Assumed Maximum Mud Pressure: psi	Flow Rate for Maximum Down-Hole HP: gpm	Total Surface Hydraulic HP	P Bit: psi	Down-Hole Hydraulic HP	Required Nozzle Area: In.²	Closest Nozzle Sizes, in.
4,000	3000	915	1600	1960	1042	.611	2 5/8 3 1/2
8,000	3000	695	1210	1960	795	.465	2 21/32 3 3/16
12,000	3000	580	1010	1960	662	.388	2 1/2 3 5/16

TABLE 2. Sample Data for Maximum Down-Hole Hydraulic Power in a 12¼-in. South Louisiana Type Hole.
Maximum economic mud pressure is assumed to be 5000 psi

Depth: ft	Assumed Maximum Mud Pressure: psi	Flow Rate for Maximum Down-Hole HP: gpm	Total Surface Hydraulic HP	P Bit: psi	Down-Hole Hydraulic HP	Required Nozzle Area: In.²	Closest Nozzle Sizes, in.
4,000	5000	1200	3500	3275	2290	.621	2 5/8 3 1/2
8,000	5000	910	2650	3275	1735	.471	2 11/32 3 7/16
12,000	5000	760	2210	3275	1450	.394	2 1/2 3 13/32

crease in pressure on the drilling of a hole similar to the hole used for Table 1. This indicates that where a total of about 1600 hydraulic hp is needed today with a mud pressure of 3000 psi, about 3500 hydraulic hp will be needed when improvements allow the mud pressure to be raised to 5000 psi.

If down-hole mud motors are developed with a pressure drop and a flow rate near the optimum, pumps required will be similar to those for jet drilling with the same down-hole power.

If down-hole mud motors with less than the optimum pressure drop are used in the future, pump power required will be higher for a given down-hole power. Amount of increase in pump power will depend on deviation of the pressure drop from optimum pressure drop.

Conclusions

Hydraulic power at the bottom of the drill string is highest when: (1) The largest practical bore is provided through the drill string; (2) mud is the lightest which is safe; (3) surface mud pressure is the highest which can be economically maintained, and (4) mud flow rate and pressure drop across the down-hole mud-operated device are optimum. Best pressure drop across the down-hole device is about two-thirds of the surface mud pressure. Optimum mud flow rate is a function of pipe and hole dimensions, mud weight, and surface mud pressure. Down-hole hydraulic power under these conditions is about two-thirds the surface hydraulic power.

Good jet drilling practice conforms closely to these conditions. Therefore, down-hole power used in jet drilling can be made higher than that achieved by present good practice only when higher mud pressures, lighter muds, or larger bore drill strings are made practical.

Down-hole mud-operated devices with a pressure drop higher or lower than optimum pressure drop require higher surface mud pressure for the same down-hole power. When pressure drop is lower than optimum, pump power required is also increased.

Pump power varies as the 1.53 power of the system pressure for maximum down-hole power. Therefore, systems now using about 1600 hydraulic hp with a maximum mud pressure of 3000 psi, will require 3500 hydraulic hp when improvements allow 5000 psi mud pressure to be used.

Appendix

These symbols are used in the derivations.

- P = Mud pressure, psi.
- P_{surf} = Mud pressure at surface, psi.
- $\Delta P_{ds\ \&\ h}$ = Pressure drop in drill string and hole, psi.
- Q = Mud flow rate, gal per min.
- HHP = Pump hydraulic hp.
- BHP = Down-hole hydraulic hp.
- K_1 = A function of hole and pipe dimensions, and mud weight relating flow rate to pressure drop.
- n = An exponent relating flow rate to pressure drop.
- K_2 = A constant relating hydraulic hp to flow rate and pressure.

Following is a derivation of the expression for the mud flow rate which gives the maximum down-hole hydraulic power.

$$P_{surf} = \Delta P_{ds\ \&\ h} + \Delta P_{bit}$$

$P_{ds\ \&\ h}$ can be approximated by:

$$\Delta P_{ds\ \&\ h} = K_1 Q^n$$

Substituting and multiplying through by $\frac{Q}{K_2}$:

$$\frac{Q P_{surf}}{K_2} = \frac{K_1 Q^{n+1}}{K_2} + \frac{Q \Delta P_{bit}}{K_2}$$

By definition:

$$BHP = \frac{Q \Delta P_{bit}}{K_2}$$

Substituting and rearranging:

$$BHP = \frac{Q P_{surf}}{K_2} - \frac{K_1 Q^{n+1}}{K_2}$$

Differentiating:

$$\frac{d(BHP)}{d(Q)} = \frac{Q\, d(P_{surf})}{K_2\, d(Q)} + \frac{P_{surf}}{K_2} - \frac{K_1(n+1)Q^n}{K_2}$$

For maximum BHP:

$$\frac{d(BHP)}{d(Q)} = 0 \qquad Q = Q_{opt}$$

When using the maximum economic P_{surf}:

$$P_{surf} = P_{limit} \qquad \frac{d P_{surf}}{dQ} = 0$$

Substituting and rearranging:

Equation 1

$$Q_{opt} = \left[\frac{P_{limit}}{K_1(n+1)}\right]^{\frac{1}{n}}$$

Following is a derivation of the expression for pressure drop across the down-hole device which gives the highest hydraulic power at the bottom of the drill string.

$$P_{limit} - \Delta P_{bit} = K_1 Q_{opt}^n$$

Substituting for K_1 in Equation 1 and rearranging:

Equation 2

$$P_{bit} = P_{limit} \frac{n}{n+1}$$

Following is a derivation of the expression for relation between pump hydraulic power and surface pressure.

Multiplying Equation 1 by $\frac{P_{limit}}{K_2}$:

$$\frac{P_{limit} Q_{opt}}{K_2} = \frac{(P_{limit})^{\frac{n+1}{n}}}{K_2(K_1[n+1])^{\frac{1}{n}}}$$

by definition:

$$HHP = \frac{P_{limit} Q_{opt}}{K_2}$$

substituting:

Equation 3

$$HHP = \frac{(P_{limit})^{\frac{n+1}{n}}}{K_2(K_1[n+1])^{\frac{1}{n}}}$$

From calculation of the mud pressure for a number of cases, it appears that with any hole situation the surface mud pressure varies approximately as the 1.9 power of the mud flow rate. Therefore $n = 1.9$.

Substituting $n = 1.9$ into Equations 1, 2, and 3:

Equation 1A

$$Q_{opt} \approx \left[\frac{P_{limit}}{2.9\, K_1}\right]^{0.53}$$

Equation 2A

$$P_{bit} \approx 0.66\, P_{limit}$$

Equation 3A

$$HHP \approx \frac{(P_{limit})^{1.53}}{K_2(2.9\, K_1)^{0.53}}$$

* * *

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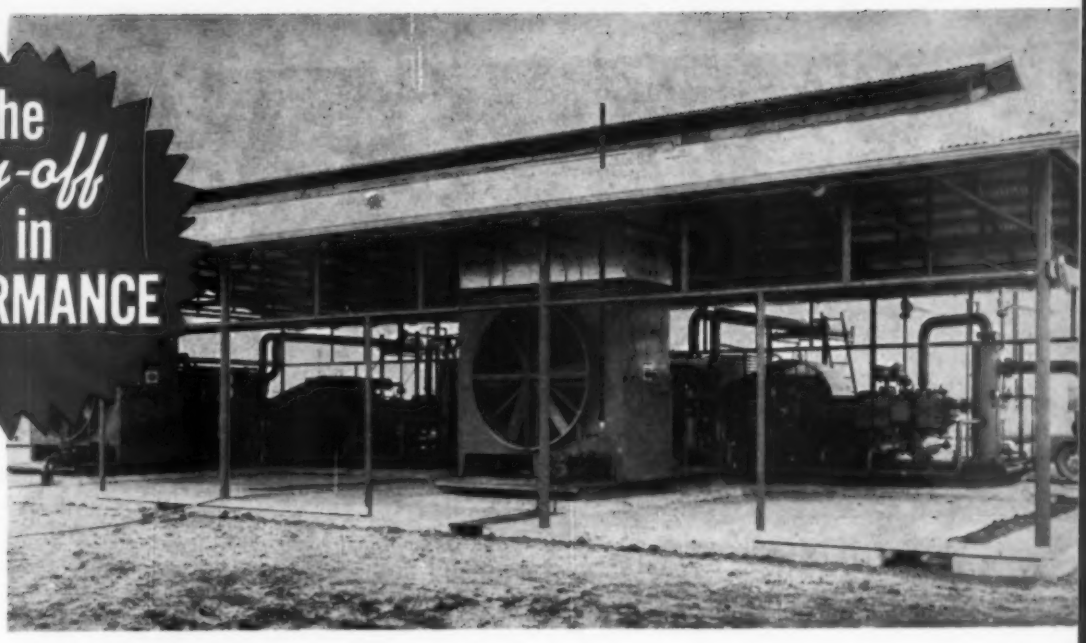

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"DON'T move a drilling rig into Alaska unless you plan to leave it here permanently." That is the advice of the only independent operator currently active in Alaskan exploratory drilling.

George Tucker, president of Anchorage Gas & Oil Development Company points out that: "The sedimentary deposits in the oil potential areas of South Alaska are deep—upward of 20,000 ft in some places. A big rig is necessary and transportation costs make it impractical to move such a rig up here, then turn around and carry it all the way back."

The number of all-weather roads is very small, Tucker continued. "Location accessibility is of paramount importance in considering a drilling job.

"We are lucky that we have both road and rail access to our area of operations. There is a good road to the nearby town of Houston and the Alaska Railroad runs right through our lease," he explained.

"But much of Alaska is muskeg country," Tucker cautioned. "Roads are built through it in much the same manner as in Canada. You go in when the ground is frozen and make a log crosslay as a mat for your power shovels. Then, when it thaws you dig deep drainage ditches on each side, using the dirt for a road bed. Topping the dirt with gravel makes a passable road."

Transportation

Robin Willis, Tucker's consulting geologist, agrees on the importance of accessibility and advises that a landing strip, where practical, be built on the location as soon as possible. "It is very valuable when emergency supplies are needed in a hurry," he pointed out.

Transportation is doubly important in Alaska because there are no oilfield supply stores, according to Tucker. "Some of the local businessmen are trying to start a supply house here in Anchorage but it will probably be next year before it gets into operation," he added.

Experience has taught AGO to keep a skilled welder and a complete machine shop, plus a large stock of spare parts right on the location. Even so the company still has supply problems.

Spare Parts

"In assembling our equipment we bought three identical mud pumps for our two rigs, keeping one for spare parts. This has worked fairly well but supplying a drilling operation up here can be both frustrating and expensive," Tucker remarked. "For example, there is only one diesel engine dealer in Anchorage who stocks any amount of spare parts. Naturally we have favored his engines. We do have other makes, however, and for one of these we had to get oil filter elements by air freight after finding out they were not available locally.

"Sure, we try to be prepared for anything but even after four years of operation we still run up air freight bills as high as $1500 occasionally.

"One time we had a fishing job," Tucker reminisced. "We hooked on to the fish, pulled it up about 3000 ft and the fishing tool dropped it. The drill collars, needless to say, were ruined after falling 3000 ft to the bottom of the hole. We had to get an oilfield hauler to truck in new ones from Houston, Texas. The trucker said as far as he knew that 5400-mile hot shot delivery was a record."

Confusion

Distance is not the only problem, according to Tucker. Confusion and delays are not uncommon in freight shipments. "We ordered some drill

←**George Tucker,** *president of Anchorage Gas & Oil Development Company, and* **Robin Willis,** *geologist, examine the total production of one of their early wildcats.*

Tucker has been prominent in Alaskan mining circles for many years. He broke into the oil well drilling business four years ago.

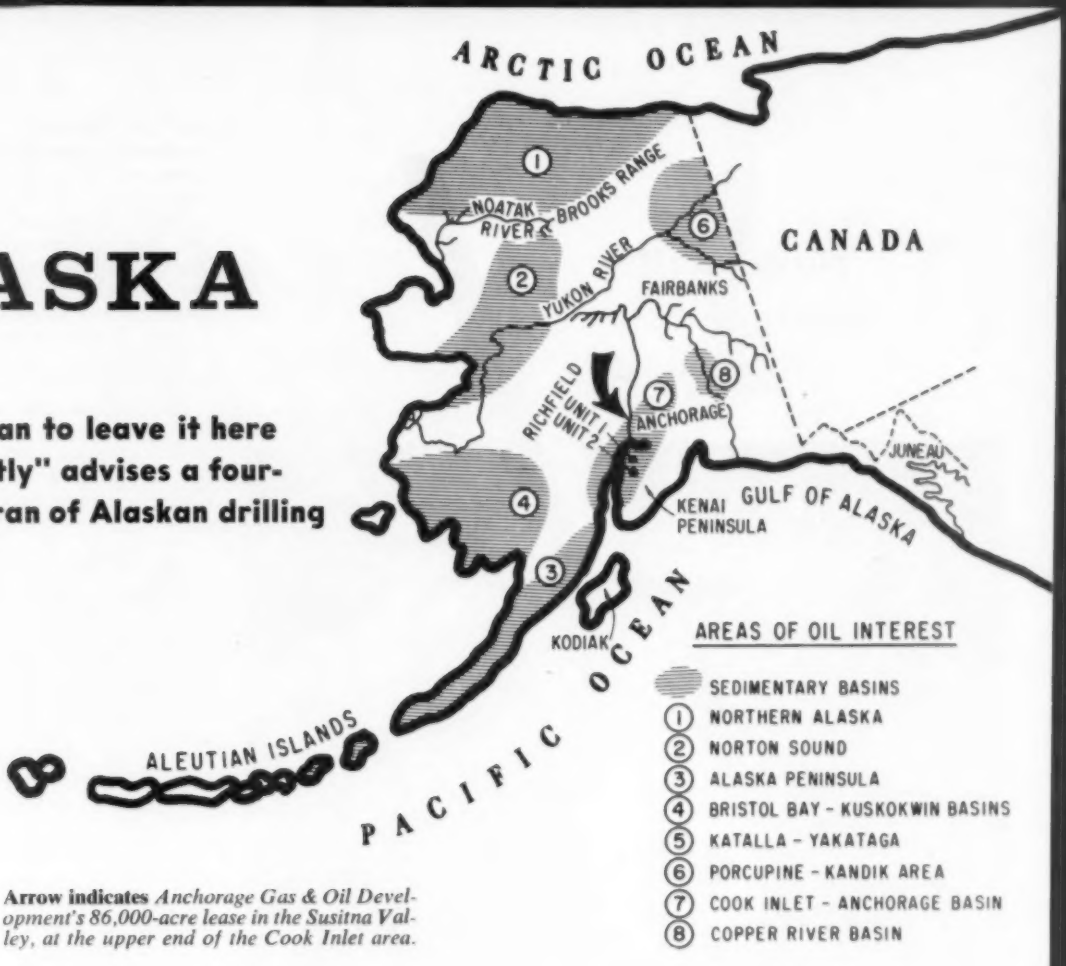
Since 1954, the company has acquired two rigs (one shallow and one medium depth), 11,000 ft of exploratory hole and lots of experience.

Willis is a Los Angeles, California, consulting geologist who has acted as consultant on three wildcat wells drilled in Alaska's "Banana Belt." Although he emphatically disclaims any title to being an authority on the area, he cautiously describes it as one of vast potential and predicts a large increase in drilling activity, beginning next year.

At the time of this writing, Willis was sniffing cuttings on AGO's Rosetta No. 3, now drilling below 6000 ft.

ALASKA

— "but plan to leave it here permanently" advises a four-year veteran of Alaskan drilling



Arrow indicates *Anchorage Gas & Oil Development's 86,000-acre lease in the Susitna Valley, at the upper end of the Cook Inlet area.*

pipe shipped from Seattle. Then we got a notice from the Alaska Railroad to come and pick it up or be charged demurrage. The trucks went to get it and no drill pipe. It turned out that all the freight agent had was a bill of lading. The pipe had been beached in Vancouver during transfer to smaller boats and was then shipped back to Seattle. Unfortunately, you can't drill a well with a bill of lading," Tucker said.

"Another time," he continued, "we ordered some drill bits by air freight. The air line forgot to drop them off in Anchorage. After locating them in Japan, the air line shipped them back here but the customs agents didn't want to let us have them until we paid duty on 'imported' drill bits."

Trucks A-Plenty

There is one bright side to the Alaskan transportation picture, however. Tucker said plenty of trucks, tractors and trailers are available to handle any kind of oilfield equipment. Also, there is plenty of fuel available and it will be delivered to the rig by tank truck at a reasonable price.

Drilling water is no problem in most areas, particularly in South Alaska. Surface water is generally available and where wells are necessary, sufficient flows can usually be found at shallow depths, says geologist Willis.

"Seasonal" Work

AGO doesn't have to worry about their surface water supply freezing for the simple reason that they don't work during the winter. "Even here in the Banana Belt we don't try to continue wildcat operations in cold weather. Human efficiency drops to about 50 percent and the additional cost of protecting equipment makes it economically impractical in many areas," Tucker said. All work is done between mid-April and early November. Development drilling would probably alter this pattern, requiring year-round operations.

The short season, along with operating costs, are important factors to be considered by a contractor contemplating an Alaska move, Tucker pointed out. He estimated the total cost of drilling a well in southern Alaska at roughly three times the cost of a comparable well in the states.

Drilling problems are much the same as in any other rank wildcat area. A wide range of bits is required because the many types of formations cause drilling conditions to change rapidly. Since there is no well control it is impossible to predict what types of rock will be encountered at any given depth.

No Troublesome Formations

Willis said there has been a wide variety of formations in the wells with which he has been acquainted but none of them have been particularly troublesome. Such things as hole deviation, wall sloughing, lost circulation and water encroachment, for example, are not considered serious problems. Formations have been hard to drill only in that it has been difficult to keep the right kind of bit in the hole because of rapid transitions from hard to soft formations.

Past experience indicates more drill collars and higher bit weights will improve penetration rates but increasing mud volume or velocity above the rate necessary to return cuttings seems to have little effect on the drilling rate, according to Tucker and Willis.

Mud Bill

Although no complicated mud programs have been required, both men recommend keeping a large supply of

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mud and chemicals on hand. One operator in a remote area encountered water and had to fly in mud, at $25 a sack, to keep the mud conditioned.

Technical services are quite expensive and not immediately available. There is one cementing truck operating out of Anchorage but it is frequently under contract to one of the major operators. Consequently, service trucks, other than cementing, must be ordered up from the United States.

AGO joined with another operator to order in a logging truck. AGO's half of the bill, to log 3000 ft of hole, came to more than $8000. The cost, of course, included travel time from Houston, Texas.

Technical Problem: Cementing

Willis pegs the lack of cementing facilities as the most difficult technical problem at present. He said the wells with which he has been associated were all cemented the old fashioned way, using construction cement—the only kind available. The cement was mixed through the mud mixing hopper and pumped down with the mud pumps. Mud jets were used to keep the batches of approximately 150 sacks mixed in the steel mud pits during the downhole pumping.

One long string of casing was cemented in this fashion, using eight batches. "The job was a success—but I still haven't thought of a good reason why," Willis ruefully admits.

This and other of the pioneering problems are expected to change next year, following an anticipated sharp rise in exploratory drilling by independent as well as major companies.

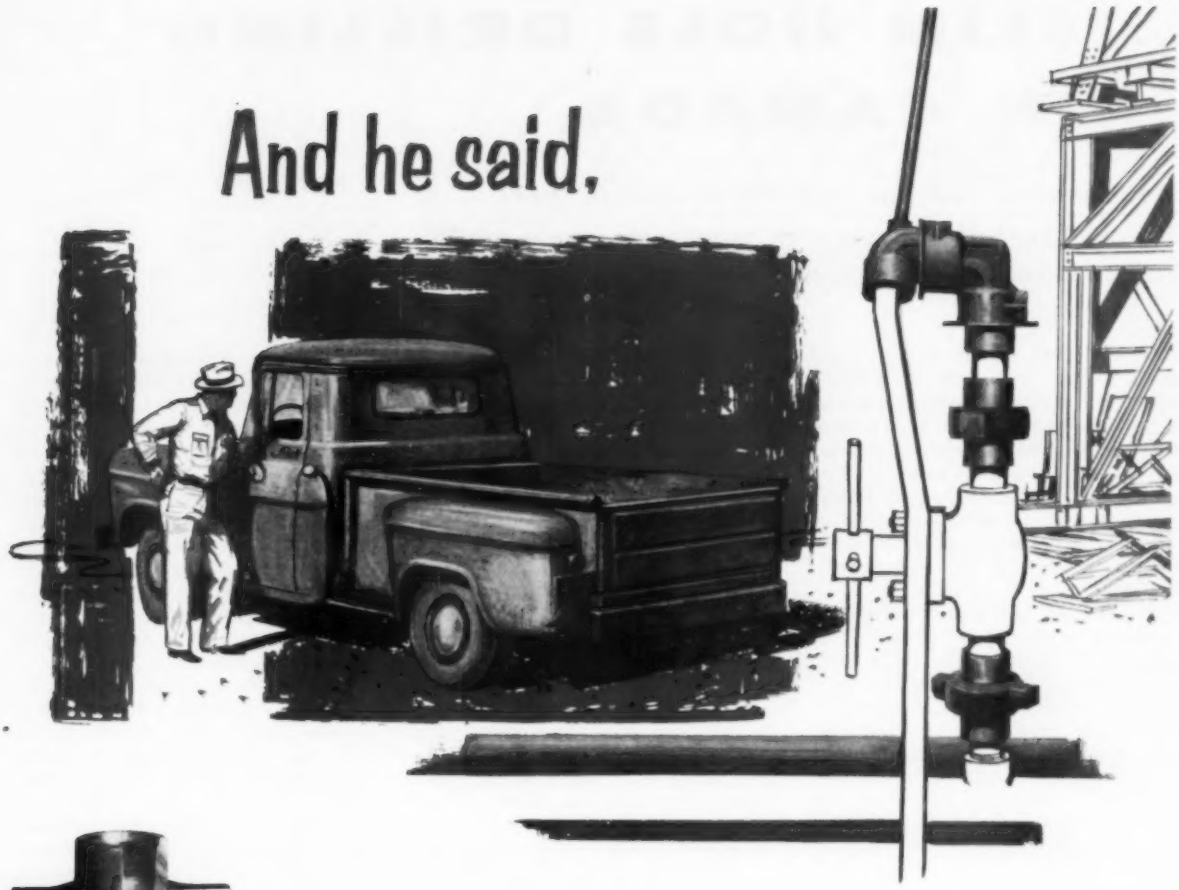
Why this almost certain anticipation of a big increase in activity?

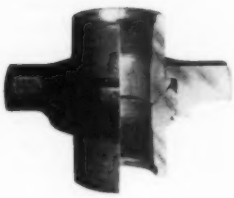
Willis said, "The Cook Inlet area, with which I am most familiar, has potential areas (leased or worth leasing) equal to or greater than all of the known producing land in California. I am reasonably certain there are some shallow pools and, of course, Richfield found production fairly deep. I can see no reason why petroleum deposits should not be found to say 20,000 ft.

"At the present time the search seems to be pointed toward anticlinal accumulations. But virtually every known geologic structure that has produced oil seems to be present there," he concluded.

Tucker expressed his faith in Alaska's petroleum potential this way: "We don't plan any contract drilling as we have all the work our equipment can handle. But, if I were bidding for work up here, I would shoot for a deal that would just pay my operating expenses and give me as much of a participating interest as I could get." ★ ★

And he said,





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SLIM HOLE DRILLING IN CANADA

No panacea for penetration problems, but . . .

Twenty Saskatchewan slim hole tests show exploration advantages, tubular savings

F. M. J. Valint
Drilling Superintendent
Hunter Drilling Limited
Calgary, Alberta, Canada

IN MAY 1957 Hunter Drilling Ltd. embarked on a 10-well "slim-hole" program in southeast Saskatchewan for a major oil company. On the first four holes a great deal of precaution was taken and quite a bit of experimenting with bits was done by varying rotary speeds and weight on bit, to be able to evaluate each and decide on the most promising methods for future operations.

It was found that high rotary speeds in the range of 250 to 280 rpm with about 2000 lb per in. diameter on the bit was essential for fast top hole drilling, also the use of a surfactant was advisable. In limestone formations the weight on bit had to be increased to 3200 lb per in. diameter while the number of revolutions per minute was reduced to 120 to be able to maintain a good penetration rate.

Twenty small-diameter holes have been drilled — 16 with 6¼-in. bits and 4 with 6¾-in. bits. It was found that the average bit life was 9 to 10 hours. This of course, meant more trips, but the rate of penetration was almost equal to the large bits.

For an efficient operation the drill collar string must be stabilized to eliminate buckling, excessive hole wiping and deviation. The use of surfactants in the mud on top hole gave trouble-free drilling. It is interesting to note that the maximum recorded deviation on these 20 holes, at no time was more than 2¼ deg.

To illustrate further, on four occasions the operator requested that a 5 11/16 in. core barrel with 6⅛-in. head be run in a 6¼-in. hole and only once we could not get to the bottom but the other three were successfully cored. On all coring, drillstem testing and logging, there were no difficulties whatsoever.

There were two fishing jobs, both for lost cones. There was a time loss of 30 hours on the first and 4 hours on the second. In the 6¼-in. hole, a poorboy basket proved to a most efficient tool to fish cones with.

Immediately after starting this program, a string of 3½-in. drill tubing was ordered. This string consists of 3½-in.-N80-9.3 lb per ft EUE tubing with 8 round thread with bucked on 3½-in. internal flush tool joints. This string was put into operation late last summer and to date has drilled a total of 50,842 ft and with no failures nor bent joints. On the first hole using this string a specially geared power tong was used as a part of the safety program. This lightweight string offered a good approach to eliminate one of the greatest hazards on a rig floor: The automatic cathead operated tong and the spinning chain. The power tong could make and break the tool joints adequately but, unfortunately, the clearance between the jaws and the tool joint were insufficient to latch and unlatch efficiently during trips. Thus, the use of the power tongs was discontinued.

Precautions in regard to this lightweight string included (1) use of button type pipe slips, (2) setting the drill tubing low enough to prevent undue bending, and (3) utilizing 20 joints of Grade E-13.3 lb drill pipe between the drill collar string and drill tubing for trouble-free operation.

When assembling the rig for slim hole drilling, extreme mobility was one of the main themes. The elimination of all unnecessary items and trimming the rig down to bare essentials resulted in discarding the two steel mud tanks. In its place one large 4.5 by 10 by 40 ft tank was built. It had three compartments and was equipped with a low-pressure, high-volume gunning and mixing system, allowing cleaning and/or mixing mud without interfering with the drilling operation. The use of one tank greatly facilitated rigging up and reduced transportation by one load.

The low-pressure high-volume mixing system supplied by a 6-in. centrifugal mud pump driven from the pinion shaft of a 300 input hp slush pump is compact and working quite satisfactorily.

As mentioned earlier, Hunter Drilling has drilled 20 holes or 88,825 ft and has compiled some comparative figures between slim holes and conventionals.

If you are expecting to hear that you can drill slim holes faster than conventional holes, you are wrong, but the comparison is much better than it was four years ago.

Hughes Tool Company supplied comprehensive data on conventional holes drilled around these slim holes on the same or adjacent sections but at no time more than 1½ to 2 miles away.

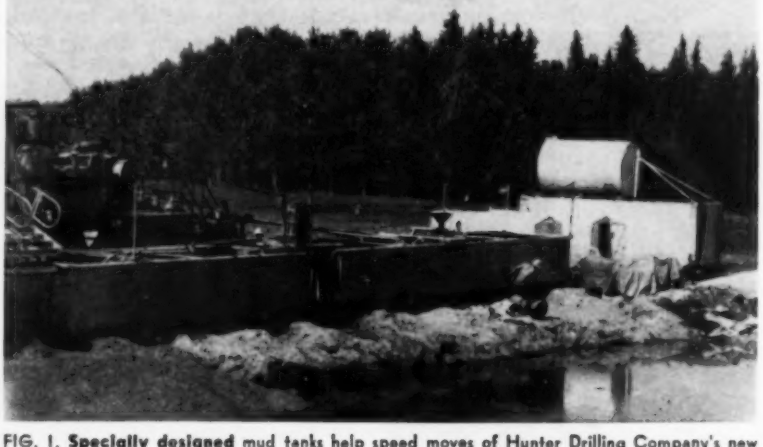
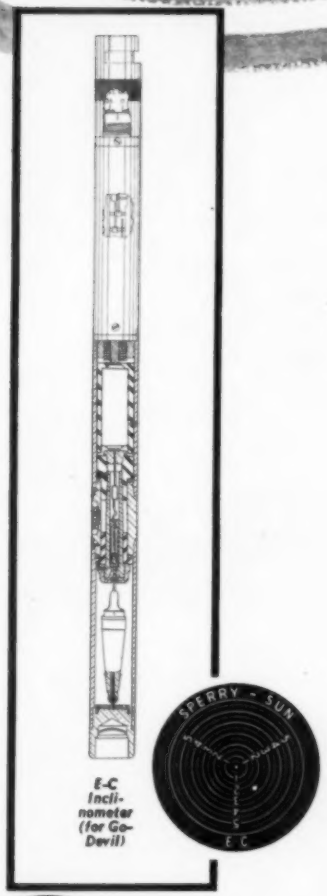


FIG. 1. **Specially designed** mud tanks help speed moves of Hunter Drilling Company's new Rig No. 2. Selector valve system permits suction from any of five compartments. Deep suction allows maximum use of mud in each compartment.

Mr. Valint presented this discussion, "New Developments in Slim Hole Drilling," at the Canadian Association of Oilwell Drilling Contractors' annual Safety Clinic in Calgary, Alberta, May 1-2, 1958.



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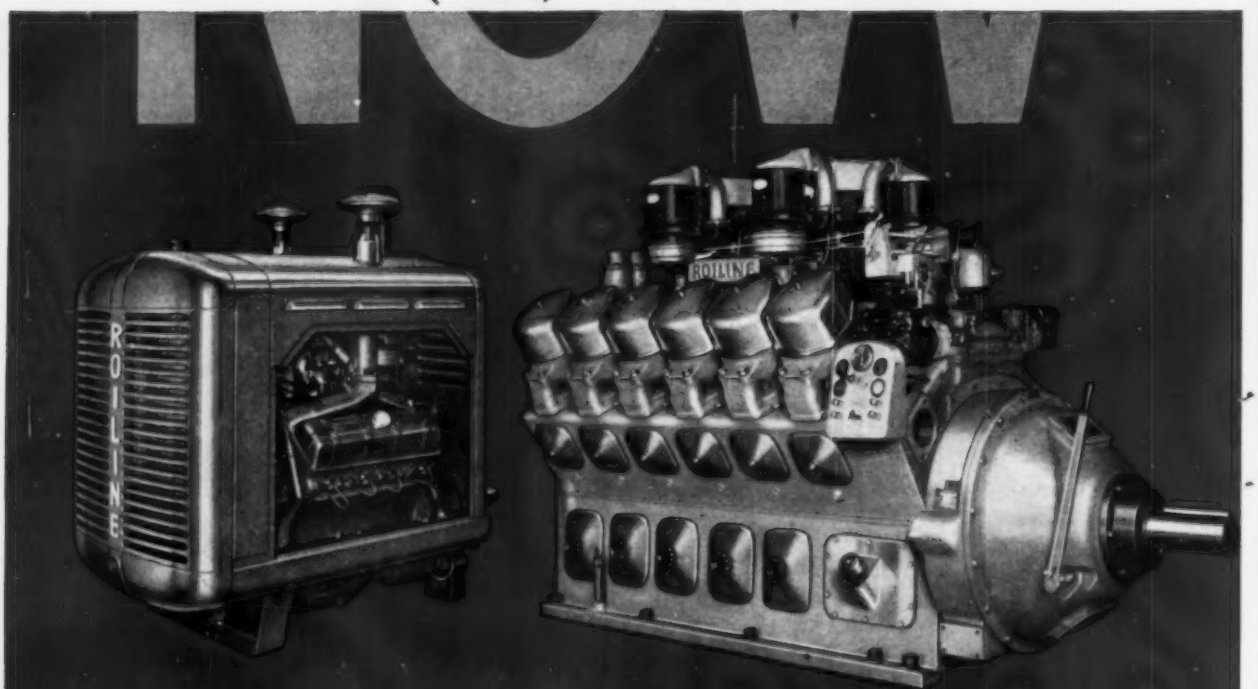

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H540	4½ x 4¼	8	540	454.... 900		68	87	103	122	138	151	164	173	178
H844	5¼ x 4½	8	844	671....1500		113	145	177	205	231	255	274	290	299
F1500	6¾ x 7	6	1503	1165.... 650	134	176	214	230						
H2000	6¾ x 7	8	2004	1590.... 650	180	240	280	300						
L3000	6¾ x 7	12	3006	2420.... 650	275	360	435	460						
L3460	7⅛ x 7	12	3468	2750.... 900	305	416	527	608	635 @ 1350 RPM					
L4000	7.54 x 7.5	12	4000	3110.... 900	345	471	595	685						

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The principal models of Le Roi gas and gasoline engines, formerly built by the Le Roi Division of the Westinghouse Airbrake Company, have been sold to the Waukesha Motor Company. The engines listed on the opposite page will be known as Waukesha "ROILINE" engines, and be built as bare engines, complete power units, and with components and accessories for special services.

Le Roi engines are widely used in the oil industry, and in various types of cotton ginning, compressor, generator, and pumping installations. They have been well-known in these fields and in other internal combustion engine applications for many years.

Waukesha has all rights to the manufacture and sale of these former Le Roi engine models and the service parts, patterns, and designs. Waukesha will produce the V-8 models H-540 and H-844 high speed transport and industrial engines in the Waukesha plant. The remainder of the engine models, including the in-line Six and large V-8 and V-12 engines, will be manufactured in Waukesha's Climax Division plant at Clinton, Iowa. ROILINE engines, parts, and service will be available in all sections of the country to owners, operators, and purchasers of these fine engines, through the ROILINE distributor organization. OEM accounts normally serviced directly by the manufacturer will be handled through the Waukesha headquarters sales office.

This expansion of Waukesha's production will enable Waukesha to manufacture and supply internal combustion engine power for any requirement from 6 to 1200 horsepower in all normal speed ranges and for use with all standard fuels.

• *The trade mark LE ROI is used under license from Westinghouse Airbrake Co., the trade mark owner.*

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This is presented in three areas: Florence, Oxbow, and Steelman fields. In Florence 6 slim holes are compared against 17 conventional holes. In Oxbow, 2 slim holes against 6 conventional holes and in Steelman 5 slim holes against 21 conventional wells. For sake of clarification, the first figure presented will be the slim hole, followed by the conventional hole.

Average Drilled	No. of Bits	Hours On Btm.	Ft/Bit	Ft/Hr
Florence Field				
3549′	10.16	101	349	35.1
3548	6.47	82.3	548	43.1
Oxbow Field				
3757	12	114.6	313	32.8
3704	7.8	99.3	476	37.3
Steelman Field				
4097	13.4	128.5	305.7	31.9
4110	8.54	129	483	31.9

It is interesting to note on the deeper holes, as indicated in the Steelman field, the overall penetration rates were identical. It appears that deeper drilling with this method could offer an economic advantage both to contractor and the operator, especially a rig rated at 5500 ft with 4½-in. drill pipe could very effectively drill to 9000 ft with 3½-in. light weight drill tubing in a 6¼-in. or 6¾-in. hole.

At present, the only economic advantage for slim hole drilling is in the savings on tubular goods. Roughly, the saving on a 5000 ft slim hole, completing it with 8⅝-in. surface, 4½-in. long string, 2⅜-in. tubing, against a conventional hole completion of 10¾ by 5½ by 2⅞-in., is about $5600.

It is hoped that the industry will in the near future accept the slim hole rig as an exploratory tool.

FIG. 2. **Covered driveshaft** (center) leads from rotary drive engine (foreground) to right-angle gear box. Arrangement prevents problems in raising or lowering derrick and simplifies maintenance. In moving, engine is lowered into substructure.

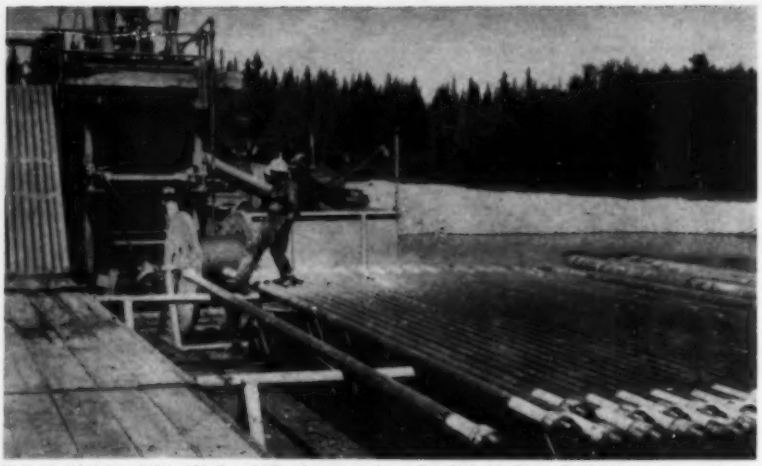


FIG. 3. **Lightweight 4½-in.** drill tubing used in slim hole drilling. Tool joints are made up several times before tubing is added to string. This is the first tubing to be used in deep drilling in Western Canada.

Rig Designed for Lightweight Moves

Challenging the problem of reducing operating costs and maintaining competitive drilling rates in Western Canada, Hunter has put into service a new, modified medium-depth rig. Attacking one of the most important cost factors, that of moving through the rugged brush country, Hunter designers aimed for compact unitization of equipment.

The result is a rig that will move anywhere in 27 truck loads, compared to as many as 35 loads for rigs of comparable size. The reduction has been set at 25 to 30 percent.

Using a string of lightweight 4½-in. drill pipe, the rig is rated for 12,000 ft. When the rig drilled its first well, an 8700-ft hole for French Petroleum Company in the Harmattan area northwest of Calgary, it marked the first time lightweight drill pipe had been used in Western Canada on a deep hole. Drill tubing has been used to some extent in slim-hole operations in Saskatchewan, however.

Among the equipment that was redesigned in modifying the rig were the mud tanks. Two 10 by 40 by 5-ft steel tanks are used instead of the three smaller ones normally used in the area. They are believed to be the largest ever used in Canada. One of the tanks is divided into two compartments with the shale shaker mounted atop one end. The other tank has three compartments.

Design features include a suction line which telescopes into the tank for convenience and safety during moves. A special valve system permits the pump to pick up suction from any one of the five compartments in the two tanks, thus allowing plenty of settling action. The suction is arranged so that the intake is not more than five inches from the bottom of the tank.

The power arrangement on Hunter's new Rig No. 2 is also of special design. The drawworks and the engines are five feet below the rig floor on a seven-foot level. Two banks of twin diesel engines provide 900 hp to the drawworks or 700 continuous hp to the mud pump. The engines are arranged for the maximum in compactness.

A separate, 300-hp diesel engine drives the 20½-in. rotary through a novel right angle gear box set-up. This unusual design prevents any conflict with the derrick leg when the mast is being raised or lowered. To speed moving operations, this engine drops into the substructure and is carried in the substructure during moves.

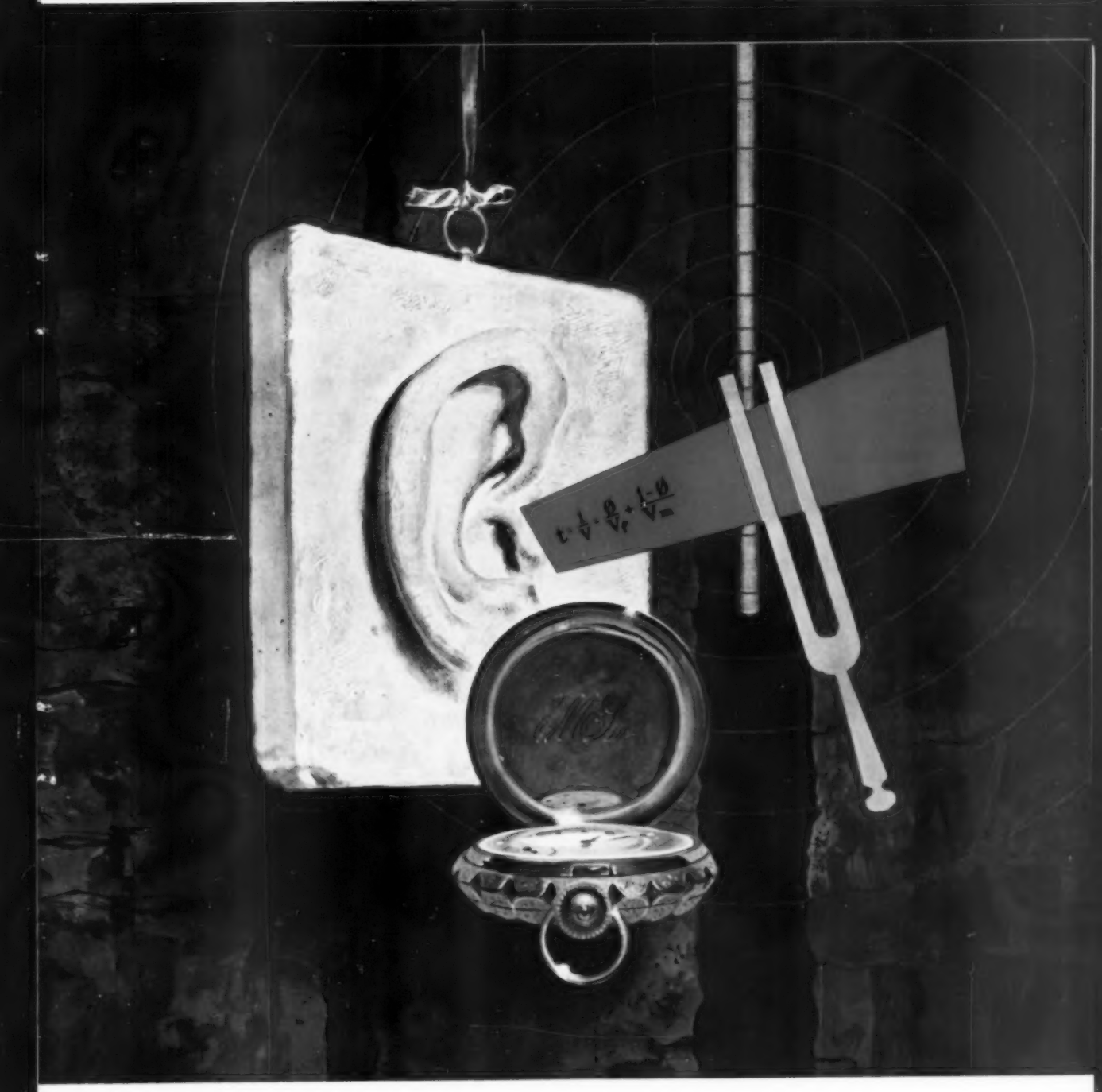
Also incorporated into the substructure is the blowout preventer closing unit and its air tank. The 30- cu ft storage tank permits opening and closing of the 12 in. blowout preventers 10 times with all rig power shut-off.

The rigging-up was done right on the first location. The rig manufacturer's technicians made the Hunter-designed modifications as the rig was set up.

Receiving special attention during the initial drilling operation were the 4½-in. i.f. tool joints on the 12.24-lb drill pipe.

"We are making up and breaking out each one of the new tool joints two or three times before running it in the hole," said a Hunter executive.

"Despite the fact and despite the minor adjustments required on any new rig, especially a modified one, we are still keeping up with the field drilling rate," he continued. "Although there are still a few problems to be worked out, we are now confident it will fulfill our expectations." ★ ★ ★



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For better interpretation of seismic surveys, look into the Schlumberger Seismic Reference Service. By contractual arrangement with the widely experienced Century Geophysical Corporation, the Sonic Log is augmented with surface tie-in and well geophone shots to provide a complete package velocity service.

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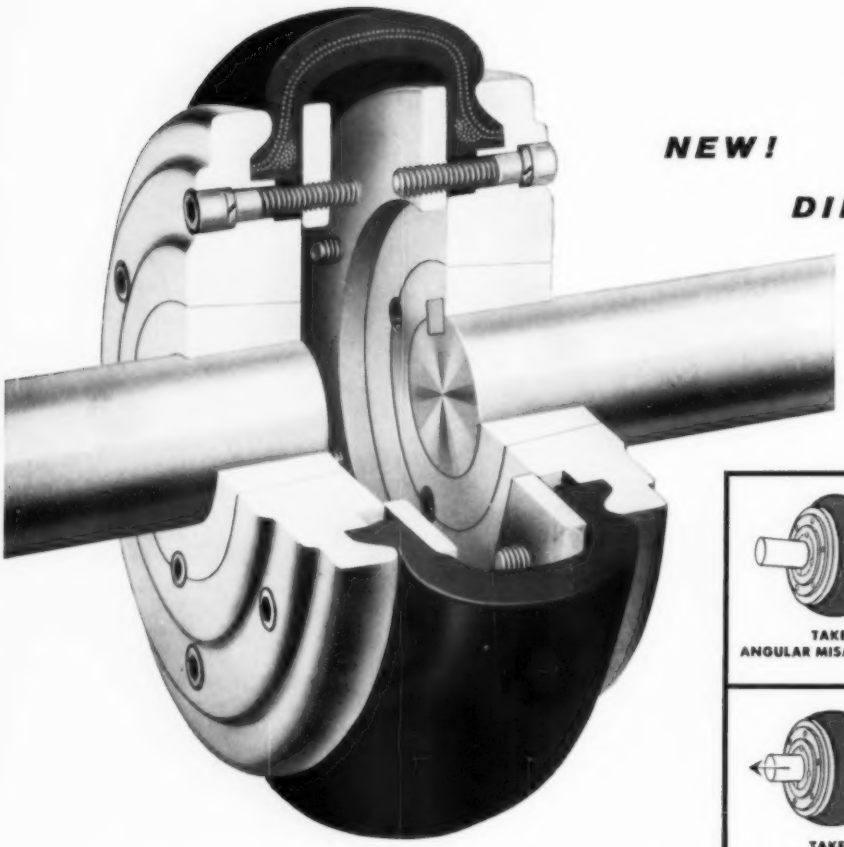

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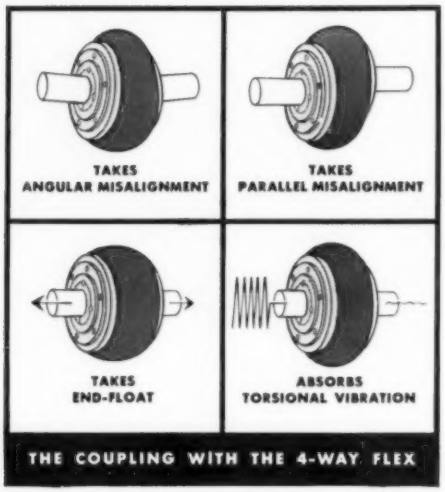

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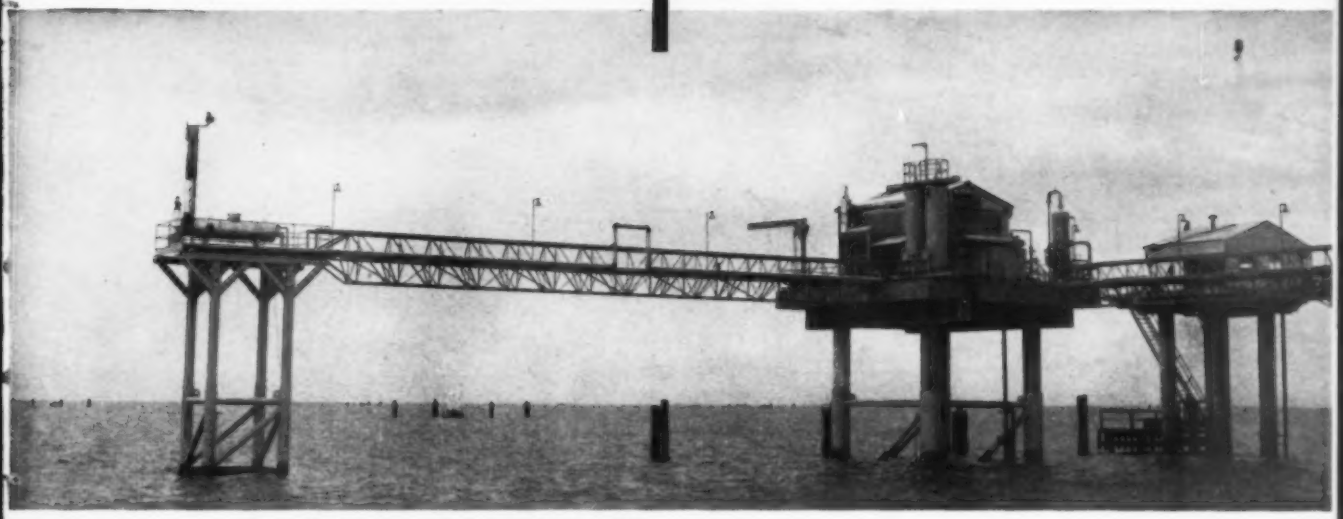

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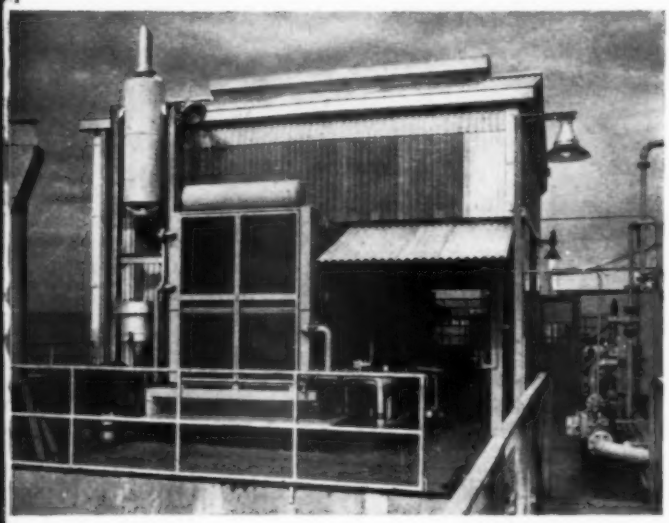

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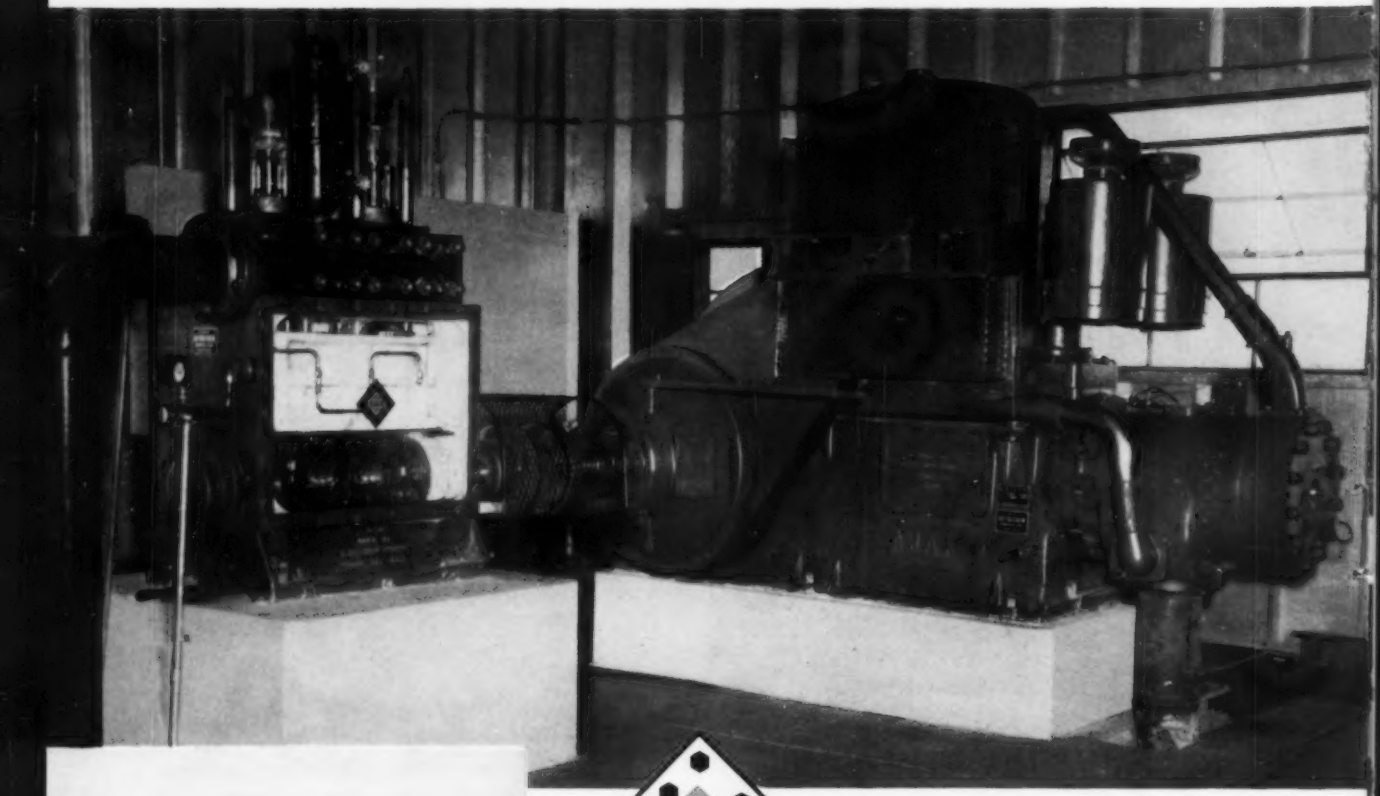

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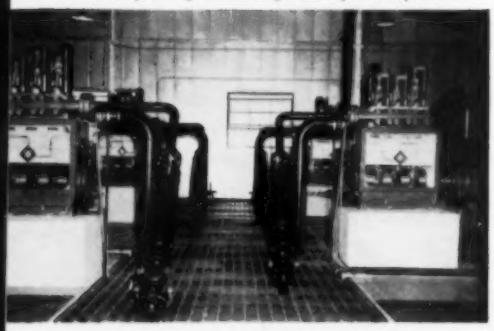

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Sahara Oil Search Gathers Momentum

Oil exploration, development continues despite French-Algerian civil strife

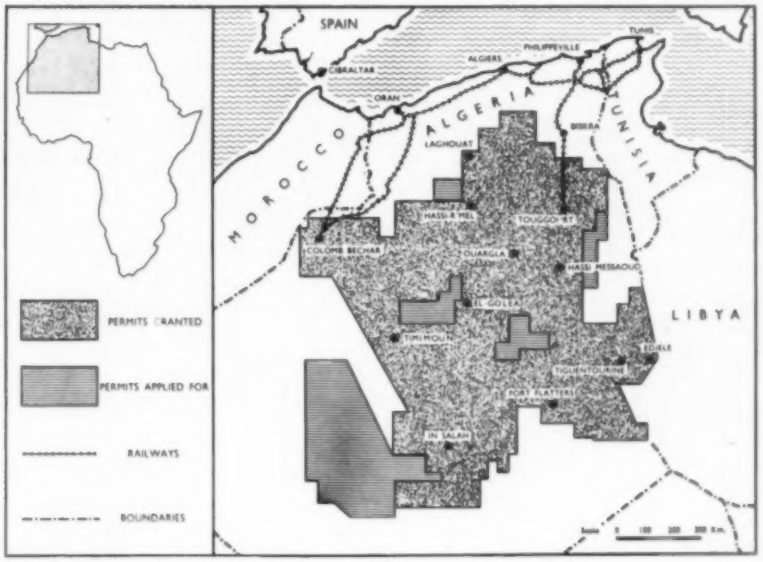
V. S. Swaminathan
London, England

RECENT SAHARA oil and natural gas finds would appear to offer an opportunity for a Euro-African essay in European economic and financial cooperation. In addition, it is a means of escape for France from undue dependence on foreign fuel and energy supplies. Several American oil companies are beginning to take a lively interest in this Sahara oil search.

The Compagnie Financiere de Recherches Petroliers (Cofirep) was formed in January 1955 to finance search for oil in French North Africa and overseas territories. Near the end of that year its capital was increased to Frs. 2000 million (one U. S. dollar = 454 francs). In 1956 a new cash issue raised it to the present total of Frs. 7000 million. The company's holdings are spread over thus:

France	. . . .	Frs. 1655 million (in 9 companies)
N. Africa	. . .	Frs. 2057 million (in 6 companies)
Overseas territories	. .	Frs. 1630 million (in 5 companies)

The companies have actually located worthwhile oil deposits. The Compagnie de Recherche et d'Exploitation Petroliere au Sahara (CREPS) has found oil in the Edjele region near the Libyan border, and natural gas reserves in the Salah sector. The Compagnie Francaise des Petroles "Algerie" (CPA), and the Societie Nationale de Recherche et d'Exploitation des Petroles en Algerie (SN REPAL) are sharing equally in the exploitation of the Hassi-Messaoud oilfield, and natural gas at Hassi R'mel.



Concession areas in Algeria encompass much of the Sahara. Most prolific discoveries have been made near the Libyan border at Edjele, Hassi Messaoud, and Tiguentourine. Other less successful or less developed exploration areas are indicated.

The very first strike in North Africa was made in the Edjele area at the beginning of 1956, and by the end of June there were 25 producing wells, all shallow. Other adjacent finds include Tiguentourine 40 miles to the west with 14 wells, the deepest reaching 8550 ft. Zarzaitine 20 miles to the north-west with three producers, and the most recently discovered find at Tin Essamerd.

A second important strike was made at Hassi Messaoud at deeper levels exceeding 7840 ft, where exceptionally high pressure was encountered. Ten wells are now producing.

According to information available in mid-August, 1957, reserves at Hassi Messaoud were placed between 600 million and 800 million metric tons. The oil bearing zones lie at depths of between 10,000 and 11,000 ft, and are 300 to 450 ft thick. Several wells are now producing. Here the oil-bearing strata is believed to be at least 522 ft deep, compared to an average productive zone of 140 ft in the Middle East.

The discovery well at Edjele found 35 deg crude oil at a depth of 1470 ft, containing 30 percent light gasoline. It was flowing 19 bbl an hour on production tests. And tests at Tiguentourine in June 1956, 43 miles to the west of Edjele, yielded more than 30 bbl of sulfur-free crude on an hour's test.

Concessions

Both French and foreign companies seeking Sahara oil concessions were recently given the first official indication of what areas may be available to them. At present, much of the Central Sahara, including the Hassi Messaoud oilfield, is held by two French companies.

Under the French oil law these two companies—CPA and SN REPAL had to give up half their Sahara permits after an initial five-year period ending October 1957. CPA has a five-year renewal of its concession on the permits of Ouargla, Oued Mamous and El Golea. SN REPAL has sought renewal of its Touggourt, Oued Fahl and Oued Mya permits.

These six permits, with the exception of Oued Mamous, located in Western Sahara near the Moroccon frontier, are adjacent and stretch from north to south in Central Sahara surrounding the Hassi Messaoud field.

This marked the beginning of a fierce bidding for the returned concessions by French and foreign companies, eager

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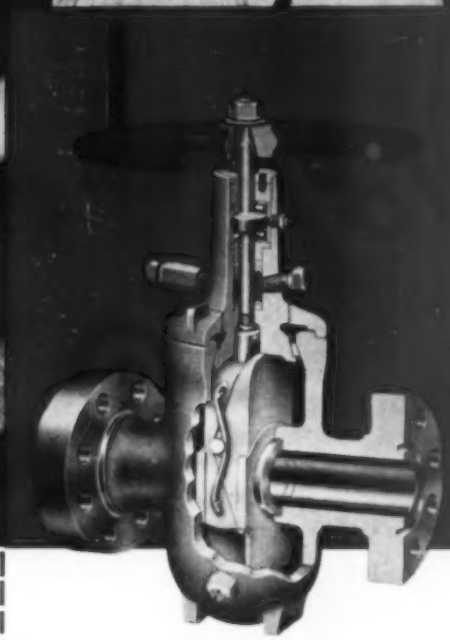

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to participate in the Sahara oil search.

The Suez Canal Company is extending its activity to the financing of oil exploration and production. It has teamed up with the Banque de Paris et des Pays-Bas to form "Comparex," with an initial capital of Frs. 20 million.

Three French banks—Lazard Freres, Rothschild Freres and Credit Lyonnais — have announced the joint setting up of a Frs. 1000 million oil investment company. Lazards have also established with the Banque Sahara, another oil exploration company, "Eurafrep," with Frs. 5000 million capital to participate with local and foreign oil interests in world-wide oil search. They have also been having talks with Newmont Oil Company, a subsidiary of Newmont Mining Corporation with a view to finance petroleum exploration should the U. S. company secure a Sahara concession. Lazards are already represented in the Compagnie Auxilaire de Petrole formed in July (1957) to participate in oil search.

An agreement was signed in August 1957 by Cities Service and two French groups PREPA and FRANCAREP to form a new prospecting group in which the American company will have a 50 percent interest. It has asked for a permit to prospect for oil in the Sahara. If conceded this will be the first direct U. S. interest in Algerian Sahara, although Jersey Standard and Socony Mobil both have small holdings in some French oil finance companies.

If the permit is granted it will mark a departure from the French Government's previous ruling that companies prospecting for petroleum and natural gas in the Sahara should at least be 51 percent French-owned. It seems unlikely that the new group would have been given its present form unless there was thought to be a good prospect of a permit forthcoming. Indeed, it was set up on time to bid for the Sahara permits to be surrendered by CPA and SN REPAL in October, 1957. Incidentally, PREPA was founded in 1953 and hitherto had confined its oil prospecting to Alsace in France.

Phillips Petroleum company was awarded exploration permits on an 815,430 acre concession in the Sahara in the vicinity of Hassi Messaoud with Compagnie Francaise des Petroles France-Afrique (COPEFA) and Omnium des Recherches et Exploitations Petrolieres (OMNIREX). Phillips holds 25 percent interest in the concession, awarded in March.

In mid-January the French cabinet discussed in committee the allocation of Sahara oil concessions to domestic and foreign oil companies. The Royal Dutch-Shell group, British Petroleum and seven U. S. "independent" companies were among the applicants for these concessions returned by the existing French concessionaires in the fall of 1957.

CPA drilling rig at unsuccessful location near Timimoun, about 430 miles south of Algiers. Exploratory drilling has been extended to almost every area.

Among problems awaiting solution is that of preserving the French interest in the Sahara while seeking to attract and hold foreign interests. In particular, France insists on retaining 51 percent of capital control on any group prospecting in her territory. But the U. S. major oil companies are holding out for 51 percent control of any group which they might join.

Problems of Progress

What oil search means in Sahara is best indicated by the activities of the CPA. It holds over 60,000 square miles under permit for oil exploration in the desert depths of Algerian Sahara on which it has spent some $39,200,000 since the 1953-54 season. The headquarters of the operation are at El Golea. To the west and east lie Timimoun oasis and Fort Flatters. For 8 or 9 months in the year, until the heat of full summer makes conditions in the desert intolerable, parties of European explorers and their assistants traverse the region, carrying out a systematic survey of geological conditions.

Following the initial aerial survey, the CPA geological parties explore the terrain collecting surface data. Two types of geophysical survey — gravimetric and seismic – are in progress. By mid-1957 more than 60,000 separate gravimetric readings had been taken. Survey teams comprise some 10 technologists, plus assistants, mechanics and drivers, and up to 100 local workers. They travel by air, land-rover, camel or on foot. For the most part they must live in tents, which are moved from site to site, together with all scientific equipment, supplies and the very large quantities of water essential to life.

In the wake of the survey parties come the exploration drilling crews, who have already sunk 27 wells with no more success than a few traces of dry gas in one or two of the permit areas. The drilling crews lead a more settled life than the survey parties and are provided with air-conditioned living accomodation and properly established kitchens and messes. They work, however, all round the year, during their 8-hour shift on the rig, even in the full heat of summer when the thermometer reaches 120 F in the shade.

The survey teams and exploration drilling crews enjoy good food, one week's holiday every four or six weeks, regular service of mail and newspapers, a good library and frequent movies. However, many of them, with families in Algiers are flown back to spend their

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week's holiday in the flats provided for their families.

The administrative difficulties of mounting an operation with many hundreds of men in this empty quarter, where no civilized amenities previously existed, are tremendous. New roads and tracks totaling 1100 miles have had to be constructed to move the heavy drilling equipment from site to site, and existing roads kept in repair. No fewer than 28 airstrips had been laid at each of the well sites, and at the main administrative centers so that equipment and supplies can be flown in regularly. As surface water does not exist except in the oasis, and as a drilling rig may well use some 17,500 gal a day, the early geological wells have had to be converted into water wells, or new water wells sunk. Tank trucks provide a regular supply to the drilling sites.

These regular trips and the less predictable wanderings of the exploration parties in their land-rovers cannot take place without careful planning and supervision, as serious breakdown in the desert wastes might otherwise mean rapid starvation and death by thirst. All journeys are routed and scheduled, and every party is in short-wave radio communication with headquarters.

Early in 1957 the French Minister of Industry and Commerce outlined the capital program for oil exploration in the next five years or so totaling $700,000,000, a substantial part of this sum to be devoted to search for and develop the Sahara oil and natural gas resources. He deemed feasible that 4 million tons of Sahara crude oil be piped out of the fields to the Mediterranean Coast by 1959.

Natural Gas

The prospect of securing natural gas direct from the Sahara to South France is under study by Gaz de France. The projected pipeline might run from Hassi R'mel to the main Sahara natural gas field 400 miles south of Algiers under the Mediterranean to Perpignan in South France. It is estimated that the line will provide France with approximately 105,900 Mcf of gas a year, virtually 75 percent of current annual consumption. Most of the gas fields are at Hassi R'mel, Hassi Messaoud and in Salah in South Algeria. Hassi R'mel alone may yield more than 176,500 Mcf a year, while by 1960 Hassi Messaoud may be accounting for 70,600 Mcf annually. Algeria's consumption of natural gas is of the order of 17,650 Mcf a year, which with the setting up of new industries, might easily be doubled. ★ ★ ★

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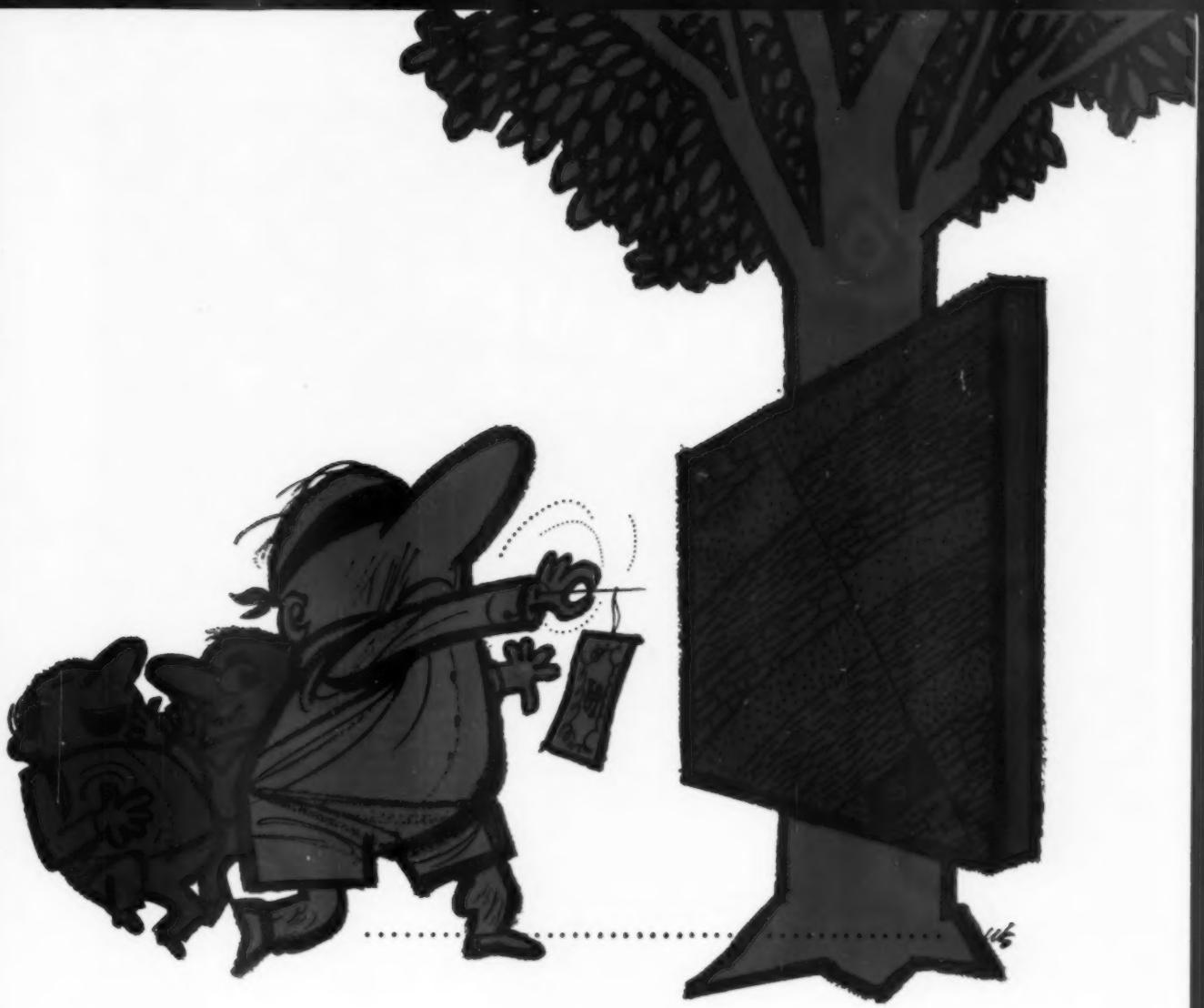

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Job: Richardson & Bass-Mecom-Freeport-Humble-LL&E-SL2414, Well No. 1-L.
Location: Lake Washington Field, Plaquemines Parish, La.
Log. Temp.: 326°F.
Detail: Squeeze Job #4—Cast-iron retainer was set at 21,020 ft. to replug and abandon perforations from 21,419 to 21,465 ft. Dry blend for this job was made up of 30,550 lbs. of UNAFLO cement, 22,800 lbs. of barite, 347 lbs. CMHEC (0.65%); 58 bbls. of water used for 100 bbls. of 17.5 lbs. per gal. slurry. Mixing time was 58 min. At the end of 1 hr. and 59 min. pressure build-up observed, with 88 bbls. squeezed. At pressure of 3,400 psi (casing pressure was 2,000 psi) retainer moved up hole and job bradenhead squeezed to completion. At 2 hrs. and 12 min. (from the start of mixing) 5,800 lbs. obtained, with 95 bbls. squeezed out. Reverse-out of remaining 5 bbls. effected. **Squeeze Job, #5, 6, 7**—All similar patterned after **#4.** CMHEC decreased to 0.56%. In all 3, final squeeze pressure was 6,000 psi. Reverse-outs were 10 bbls., 10 bbls., 12 bbls., respectively. No difficulty on any reverse-outs because reversed cement quite fluid on recovery.

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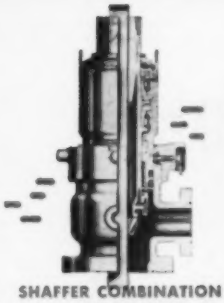

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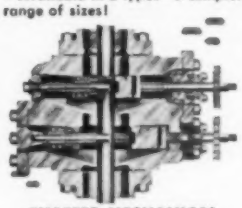

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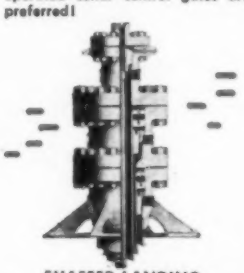

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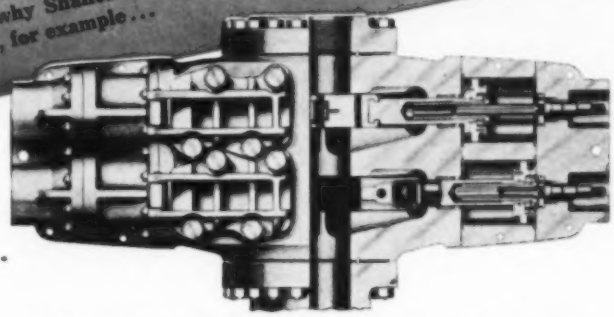

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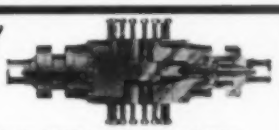

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The Plunger Lift Method of Oil Production

PART 5 WELL SELECTION AND APPLICATIONS—CONCLUSION

Carrol M. Beeson,
Petroleum Engineering Department, The University of Southern California, Los Angeles, California

Donald G. Knox and John H. Stoddard,
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USE OF EQUATIONS AND FIGURES WITHOUT PLOTTING OPERATING LINE

WHEN THE STATIC BOTTOM-HOLE PRESSURE and the productivity index are known or may be estimated, a well's operating line may be drawn on a nomograph, as has been described earlier. Even when such bottom-hole data are not available, the equations for net operating pressure and gas-liquid ratio gradient may be used to advantage.

Any oil or gas well has limitations as to pressure or volume of gas, and one of these factors is more critical than the other. By substituting a value for the more critical factor into the appropriate equation, the size load may be computed. This computed size load may be substituted into the companion equation, and a value may be calculated for the less critical factor. This process may be repeated, starting with various values of the more critical factor.

The above method is illustrated in Table 4, and it may be applied either before or after installing free piston equipment. Before installation, the calculations are used in predicting future performance. After installation, the method is used in adjusting the operating conditions to those most suitable for the well.

WELLS SUITABLE FOR FREE PISTON PRODUCTION

General Considerations

The free piston can be applied to all wells that are within its capacity and where sufficient gas and pressure are available. These include weak flowing wells, small producers with high gas-oil ratios, and wells on gas lift that are using excessive volumes of gas. Also are included wells where the accumulation of bottom-hole water, paraffin, or an emulsion is a production problem.

TABLE 4. Example Wells for Use of Equations.

EXAMPLE WELL WITH LIMITED NET OPERATING PRESSURE	
Data	
Tubing Size, O D, In.	2⅜
Tubing Depth, Ft.	8000
Anticipated Minimum Tubing Pressure, psi	40
Pressure of Outside Gas Available, psi	500
Anticipated Production Rate, B/D	70
Solution by Equations or Figures	
From data, Net Operating Pressure, psi	460
From Equation 1 or Fig. 2, size load, Bbl/cycle	1.47
From Equation 3 or Fig. 1, Gas-Liquid Ratio Gradient, CF/B / Ft/1000	466
Probable Gas-Liquid Ratio, CF/B	3728
Probable Daily Gas Volume, Mcf/D	261
EXAMPLE WELL WITH LIMITED GAS-LIQUID RATIO	
Data	
Tubing Size, O D, In.	2⅞
Tubing Depth, Ft.	8600
Minimum Tubing Pressure, psi	60
Gas-Liquid Ratio, CF/B	4000
Solution by Equations and Figures	
From data, Gas-Liquid Ratio Gradient, CF/B / Ft/1000	465
From Equation 4, Size Load, Bbl/cycle	2.07
From Equation 2 or Fig. 4, Net Operating Pressure, psi	346
Probable Maximum Casing Pressure, psi	406
EXAMPLE GAS WELL UNLOADING WATER TO ATMOSPHERE	
Data	
Tubing Size, O D, In.	2⅜
Tubing Depth, Ft.	4200
Casing Pressure, psi	400
Water Production Rate, B/D	4
Solution by Equations or Figures	
From data, Net Operating Pressure, psi	400
From Equation 1 or Fig. 2, Size Load, Bbl/cycle	1.94
From Equation 3 or Fig. 1, Gas-Liquid Ratio Gradient, CF/B / Ft/1000	366
Probable Gas-Liquid Ratio, CF/B	1537
Probable Daily Gas Volume Used in Unloading, Mcf/D	6.46
EXAMPLE GAS WELL PRODUCING TO SALES LINE	
Data	
Tubing Size, O D, In.	2⅞
Tubing Depth, Ft.	4000
Sales Line Pressure, psi	650
Casing Pressure, psi	860
Water Production, B/D	150
Solution by Equations and Figures	
From data, Net Operating Pressure, psi	210
From Equation 2 or Fig. 4, Size Load, Bbl/cycle	1.99
Cycle Frequency, Cycle/day	75
Cycle Time, Min/cycle	19
From Equation 4, Gas-Liquid Ratio Gradient, CF/B / Ft/1000	587
Probable Gas-Liquid Ratio to Lift Water, CF/B	2348
Probable Daily Gas Volume Used in Lifting, Mcf/D	352

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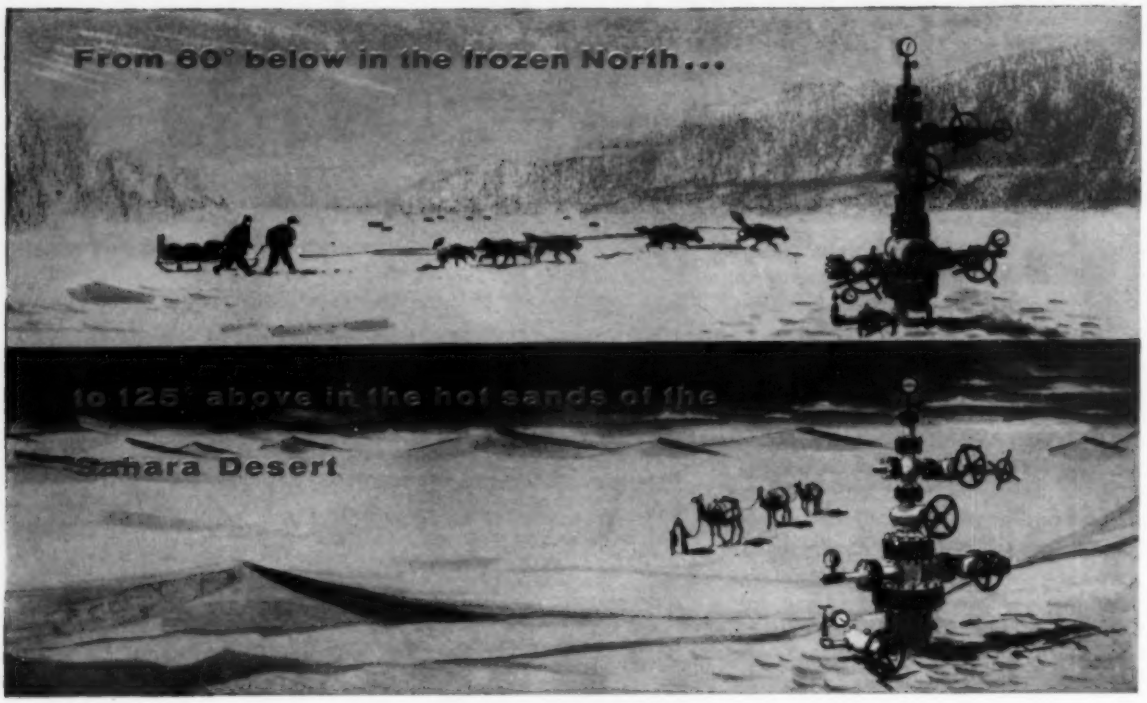

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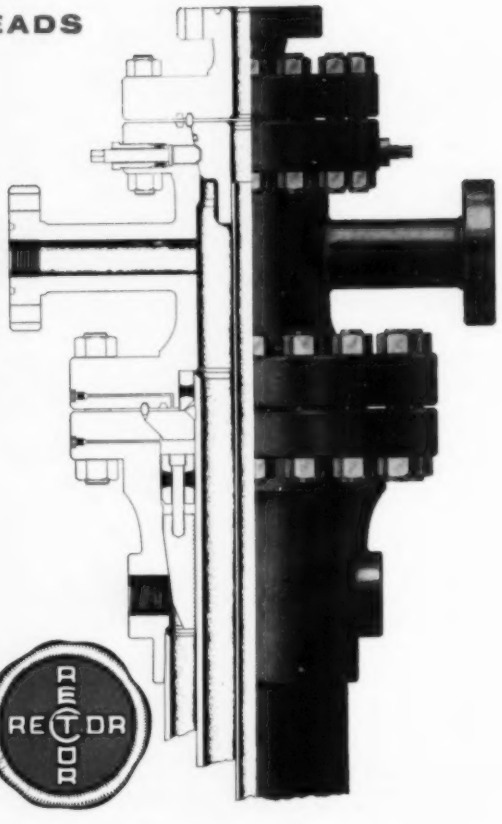

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Free piston production is especially suitable for the deeper well with a medium to high static bottom-hole pressure and low productivity index. This method may be economically applied to the difficult intermediate step between flowing and pumping, usually when gas-oil ratios are high. The plunger is considered a depletion device for deep, tight formations.

The standard free piston installation consists of surface controls and a simple, open system without a tubing packer. Experience has proved that lower flowing bottom-hole pressures can generally be obtained by this system than by any other gas-lift method.

In some wells, it becomes necessary to lift small loads of oil each cycle. In such cases, a plunger acting as a piston can lift the oil with less pressure, less volume of gas, less slippage, and less chance of forming emulsions than is the case with any other gas-lift method.

For best results, oil gravities probably should be above 24 deg API. A free piston will produce wells with water cuts ranging from 0 to 100 percent, providing the gross production rate is within the capacities listed later in this section.

The piston is excellent for preventing the build-up of paraffin on tubing walls and often in flow lines as well. This is due to the combination of the intermittent gas flows, followed by warm slugs of liquid, and the scraping action of the piston.

The piston can operate in the tubing, no matter how crooked the hole. It has not been determined how great would have to be the deflection from the vertical to cause an adverse effect upon piston operation. But it is believed that a steep angle would tend to slow the piston, so that its maximum effectiveness could not be realized.

Capacities

The maximum (gross) production rates of wells ordinarily considered suitable for free piston production are as follows:

	Plunger Size, In.	
	2 in.	2½ in.
Depth—Ft	Bbl per day	Bbl per day
4000	130	190
6000	115	175
8000	105	160
10000	95	150
12000	85	140

SELECTING WELLS FOR FREE PISTON PRODUCTION

The suitability of an oil well for the free piston system is best determined by plotting the well's operating line on a nomograph, as described earlier. A helpful preliminary apprasial, however, may be made by using Fig. 7 or 8 to determine whether a well is a possible candidate for free piston production.

Use of Fig. 7 and 8

The curves in Fig. 7 and 8 represent probable requirements of gas and pressure. The gas-liquid ratio* is plotted against the net operating pressure. The latter is the amount of the casing pressure that is over and above the trap or separator pressure.

Because these curves represent average values, 2000 ft should be subtracted from the well's tubing depth in using the curves to determine whether a well's operating line should be plotted.

In using the figures, proceed as follows, depending upon whether the well must rely entirely on formation gas or there is additional gas available from some outside source; that is, depending upon whether gas volume or pressure is the more critical factor.

*In computing the gas-liquid ratio for Fig. 7 and 8, the trap or separator pressure was taken equal to zero.

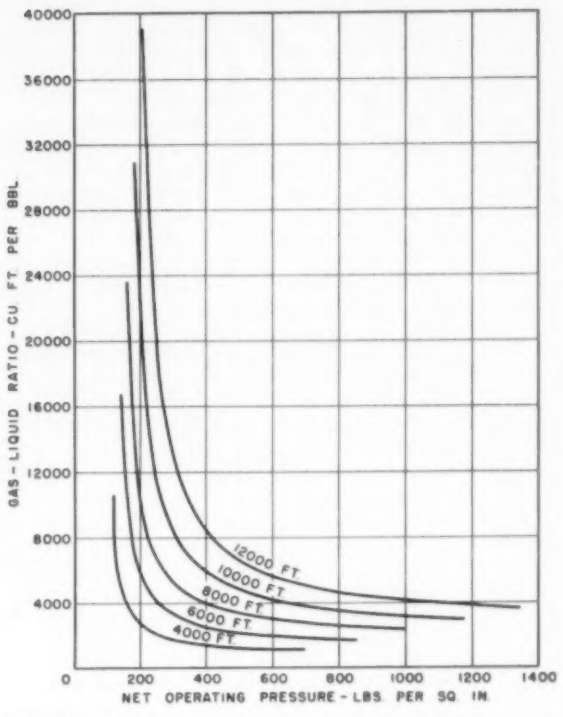

FIG. 7. **Application curves** based on gas and pressure requirements with 2-in. free piston.

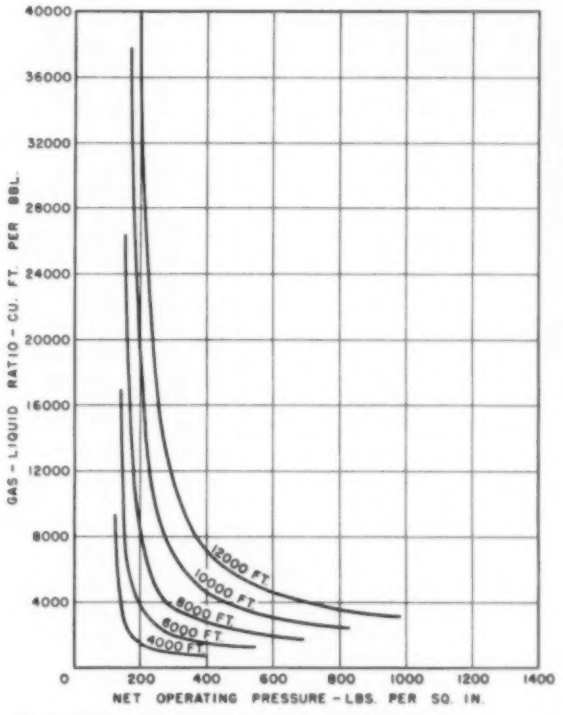

FIG. 8. **Application curves** based on gas and pressure requirements with 2½-in. free piston.

Well depends entirely on formation gas. Use Fig. 7 for a well with 2-in. tubing or Fig. 8 for a well with 2½-in. tubing. Starting at the well's gas-liquid ratio, proceed horizontally to a curve representing the well's tubing depth less 2000 ft. Directly below this point, read the value of net operating pressure. If this pressure appears feasible, the well's operating line should be plotted for a complete analysis.

Well has gas available from some outside source. Select a casing pressure acceptable for producing the well. Subtract from this value the pressure of the flow line or separator. Enter Fig. 7 (for 2-in.) or Fig. 8 (for 2½-in.) at this net operating pressure, and proceed vertically to a curve representing the well's tubing depth less 2000 ft. Horizontally opposite this point, read the value of gas-liquid ratio. If this ratio appears reasonable, the well is a possible candidate and its operating line should be plotted.

INTERMITTENT FLOWING AND FREE PISTON SYSTEM

Before completing a new well, it may be profitable to estimate the likelihood of the well developing into one suitable for free piston production. In this regard, it is helpful to project into the future the probable ranges of the well's static bottom-hole pressure and productivity index.

These estimated values may be used to plot a series of operating lines on a nomograph by the method described earlier. These lines will indicate (1) whether the well will become suitable for free piston, (2) when to start the piston, and (3) whether the well may be economically depleted by free piston production.

The operating lines plotted for the well at various estimated stages of production may indicate that the well will become suitable for free piston production. In this case, it will pay to consider equipping the well at the start for the intermittent flowing and free piston system.

This system involves the following producing steps, during any of which outside gas may be added:

1. Continuous flow.
2. Intermittent flow by automatic stopcocking.
3. Producing with free piston.

EQUIPPING WELLS WHEN COMPLETED

Tubing Program

1. When run, the tubing should be drifted or sized to 1.915 in. for the 2-in. piston or 2.355 in. for the 2½-in. piston.

2. The tubing should be the same size all the way down and should be run as deep as practicable, since this will help in the later stages of depletion.

3. An API pump shoe may be run on the bottom of the tubing string, for later setting a footpiece spring.

4. If a packer is desired in the well, consideration should be given to installing a side-door choke at the same time. In wells suitable for such a practice, this will permit the use of outside gas without removing the packer, in case additional gas is finally required for the operation of a free piston.

Christmas Tree

A free piston Christmas tree should be installed, so that it will later accommodate a piston. The master gate valve should have a full, round opening of the same size as the tubing string. Such a tree is just as useful for all prior operations, and no major change need be made when ready to install the rest of the free piston equipment.

Well Starting

There should be a means for starting the well, after natural flow ceases. Gas from an outside source, such as a compressor, should be available at sufficient pressure for starting the well, or kick-off valves should be installed to permit the use of gas at a lower pressure. Preferably these should be outside valves which will permit normal passage of the standard piston through the string of tubing.

Intermittent Flow Cycle Controller

In the producing step involving intermittent flow by automatic stopcocking, a cycle controller would be installed to open and close the flow line. This controller should be the same one needed later with free piston production.

INTERMITTENT FLOW AND FREE PISTON ADVANTAGES

The system involving intermittent flowing and free piston has several advantages over any other system of producing a well. Some of the advantages are:

1. The system is so versatile and flexible that it will handle a well throughout wide ranges of bottom-hole conditions, production rates, gas-oil ratios, and water cuts.

2. The formation gas is always used in lifting, and is never a detriment.

3. The tubing need not be pulled to progress through the steps outlined in this system, from completion to the final step of depletion by free piston production.

4. If no tubing packer is used, as is generally recommended, the operator will have the advantage of more easily obtaining bottom-hole data. This is especially true, if there is installed a bonnet designed for running instruments into the annulus.

5. All controls are located at the surface.

6. Since the well is always in a state similar to natural flowing, there is a beneficial effect on the formation.

GAS WELL APPLICATIONS

A recent and fast growing application of free piston production is being made in gas wells for removing liquid accumulations which hold back gas production. It has been found that gas production is substantially increased by the automatic removal of even very small volumes of water per day.

It is necessary to flow some gas wells at very high rates to produce water, or to blow the wells frequently to atmosphere in removing the water. In such cases, it is found advantageous to use a piston to gain better control in producing the well. Removing the water with a piston, while producing gas at a lower rate, results in a much more gentle action on the formation.

In a well which has sufficient pressure, a piston may operate while the gas is being produced through a separator directly to the sales line. Where this is not practicable, the gas should be produced from the casing to the sales line, and the piston should be cycled periodically to remove liquid from the tubing to the atmosphere or low-pressure separator. In this latter application, it is necessary to use the trigger to insure a minimum loss of gas during the periodic unloading of the tubing.

Ordinarily a timer is used for the automatic control of the free piston in gas wells. It is possible, however, to operate the piston manually instead of automatically, especially if not more than two cycles per day are required.

The free piston, being a versatile tool, may be operated in a variety of ways to produce gas wells with wide ranges of gas and liquid production rates. The volume of produced gas may be any value above the minimum gas requirement described in the section entitled "Selecting Wells for Free Piston Production." The liquid capacities listed in the section entitled "Wells Suitable for Free Piston Production" apply also to free piston operation in gas wells.

This is the final installation of a five-part series entitled "The Plunger Lift Method of Oil Production" begun in the June 1958 issue of The Petroleum Engineer. ★ ★ ★

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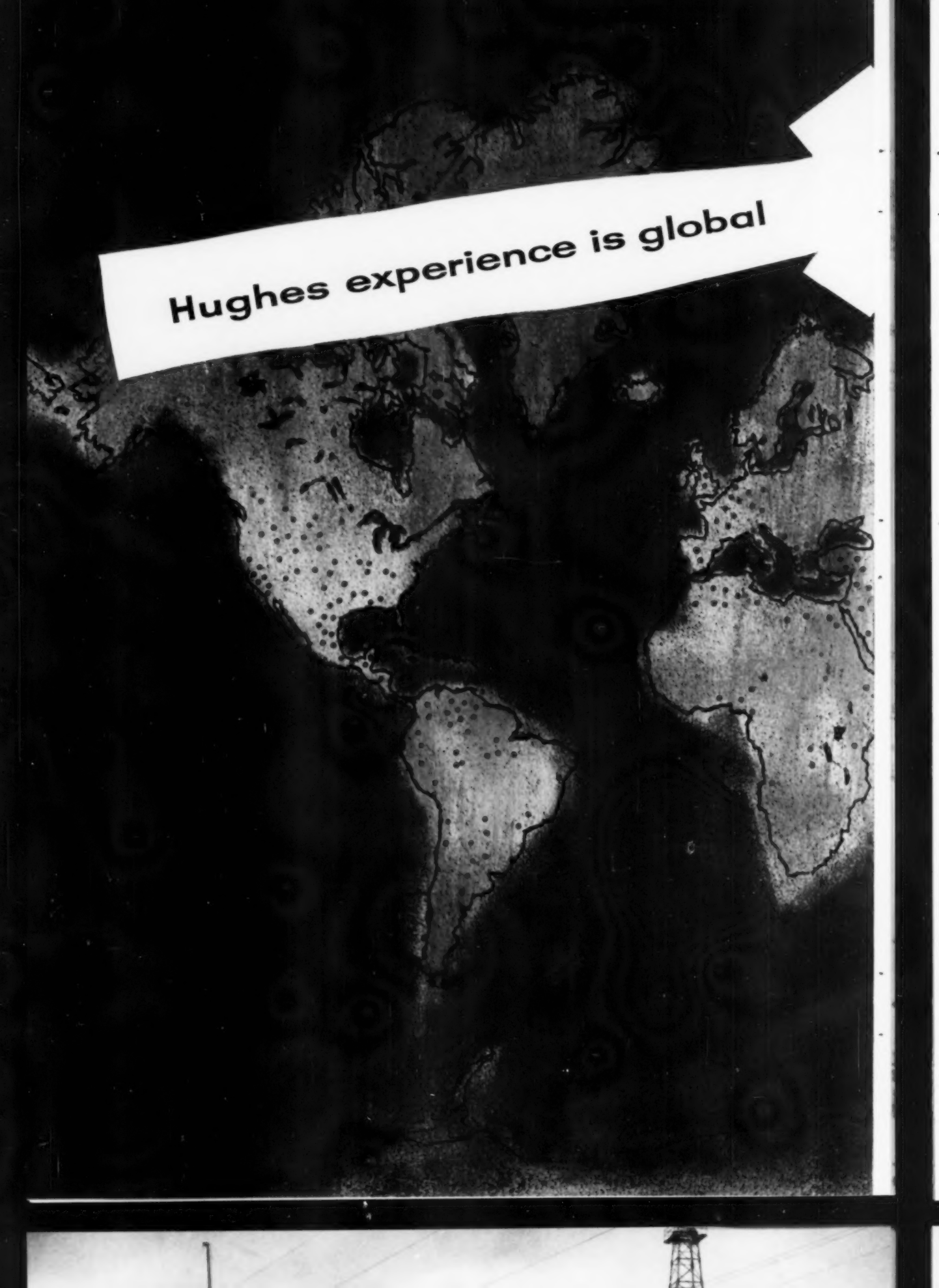
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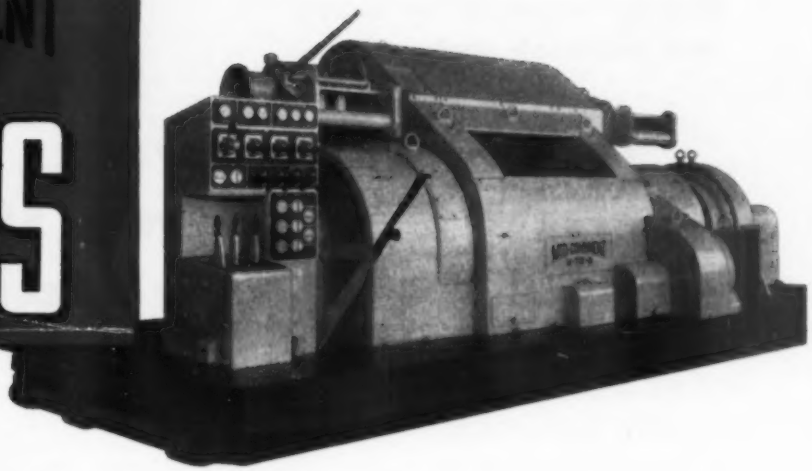

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SIZING UNIT PUMPERS

To begin, it is well to consider just what a unit pumper is and what it does, and to study the relationship of the various formulas used in sizing a unit for given conditions to the unit pumper itself.

Fig. 1A is a diagrammatic illustration of a simple set of balance scales. Equal weights at equal distances from the pivot result in balance. If the scales were set in motion, they would move for a long time before coming to rest. In fact, if it were not for friction (air resistance and friction in the pivots) in the system, it would move forever.

The relationship of the scale balance to a unit pumper is illustrated in Fig. 1B, which represents a skeleton unit pumper with 5000 lb of sucker rods hung on one end and the center of gravity of a counterbalance weight of 5000 lb at the same distance from the center iron assembly on the other end. This, in effect, is the same situation as illustrated in Fig. 1A.

In Fig. 1C, 2000 lb of fluid weight has been added on the pump plunger at the end of the sucker rod string. This weight is imposed on the pump plunger during the upstroke, but not on the downstroke. Leaving the same 5000 lb of counterbalance at the other end of the beam results in a load of 2000 lb of unbalanced weight during the upstroke. However, as shown in Fig. 1D, there is no fluid weight on the pump plunger during the downstroke and the result is no unbalanced weight to lift. Therefore, the upstroke load and the downstroke load are unequal.

Fig. 1E and 1F show the effect of adding to the counterbalance a weight of 1000 lb, or one-half the weight of the fluid, with all other conditions remaining the same. This results in having to lift the same unbalanced load of 1000 lb on both the upstroke and the downstroke. From this illustration is derived the best theoretical counterbalance, as follows:

$$\text{Best Theoretical Counterbalance} = \text{Bouyant Weight of Rods} + \tfrac{1}{2}\ \text{Fluid Weight}$$

$$= WR_b + \frac{WF}{2}$$

The bouyant weight of the rods is used since they are in fact immersed in well fluid and will weigh less than in air.

In order to determine the peak torque developed in the gear reducer during pumping operations, it is necessary to apply the peak polished rod load on the unit. (Peak polished rod load can be calculated from several formulas, all of which consider rod weight in air and in well fluid,

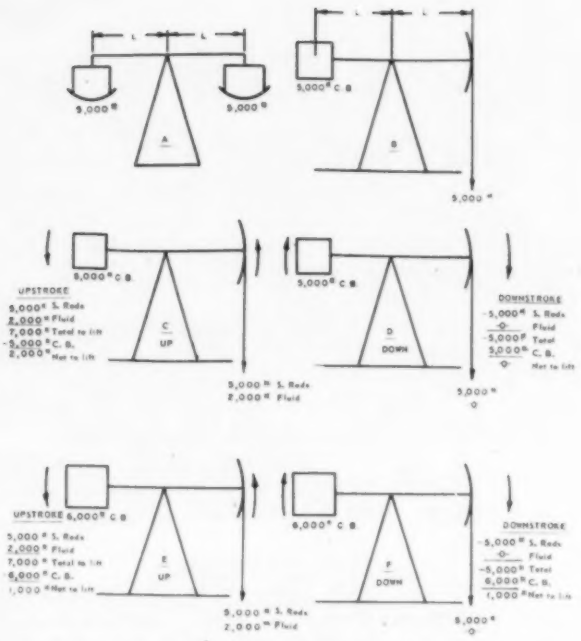

FIG. 1. Determination of best theoretical counterbalance may be derived from relationship of a unit pumper to a set of simple balance scales.

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length of pumping stroke, strokes per minute, fluid weight, and other variables. Development of these formulas will not be shown in this paper.) Fig. 2 is a diagrammatic illustration of a unit pumper and shows the basic parts to be considered in studying peak torque. It can be seen that the unbalanced load at the wrist pin will be the load at the polished rod less the counterbalance, or at the peak load, PPRL — CB. Torque on the gear reducer will be that torque at the center of the low-speed shaft. Obviously, this torque is the product of the unbalanced (net) load at the wrist pin and the distance from the center of

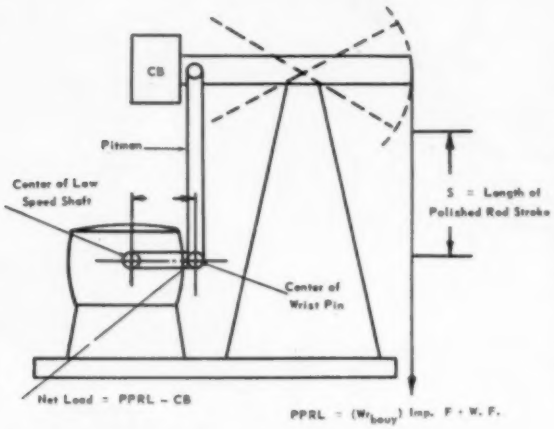
CB
Pitman
Center of Low Speed Shaft
S = Length of Polished Rod Stroke
Center of Wrist Pin
Net Load = PPRL - CB
PPRL = (Wr_bouy) Imp. F + W. F.

FIG. 2. Diagrammatic illustration of a unit pumper.

the low-speed shaft to the center of the wrist pin. In an equi-centered API unit pumper, this lever arm distance is always one-half the length of the polished rod stroke. This relationship may be stated algebraically as follows:

$$\text{Peak Torque} = (\text{PPRL} - \text{Best CB}) \times \left(\frac{\text{Polished Rod Stroke}}{2}\right)$$

$$= \left[\text{PPRL} - \left(\text{WR}_b + \frac{\text{WF}}{2}\right)\right] \times \frac{\text{S}}{2}$$

This equation does not consider impulse factors, inertia, friction, slippage, etc., but there are several assumptions usually made in sizing unit pumpers, such as:

1. Friction losses will be "normal."
2. Gravity of the fluid lifted from the bottom of the hole will ultimately be that of water.
3. Unit geometry will not be so adverse as to affect materially the torque, etc.
4. Peak load is at a crank angle of 90 deg, where rotary counterbalance is at maximum.

Actually, none of these conditions ever hold exactly true, but usually they tend to "average out." Where one is excessive, it is compensated for by another being less. Many unknown factors are present in any installation, but all factors which are known must be considered as to the material effect they will have on the installation.

UNIT PUMPER GEOMETRY

After the unit is set on the location, the actual peak torque at the center of the low speed shaft must be determined in order to counterbalance the unit so that the least peak torque will be developed. This involves a study of the geometry of the unit, as illustrated in Fig. 3. From this figure, several facts are readily seen:

1. Considering the unit to be running clockwise, it is apparent that less than one-half of the circle circumscribed by the wrist pin about the low speed shaft is consumed during the upstroke, and more than one-half during the downstroke. Two factors (among others) contribute to this: (1) The equalizer "moves" toward the well at the end of the downstroke relative to its position at the middle of the stroke, since it travels through an arc, and (2) the pitmans do not remain vertical but rather trace out an "X" configuration.
2. The factors described above result in mechanical inefficiency. For example, the application of a 1000-lb load at the polished rod might result in 1100 lb at the wrist pin. This is what is usually referred to as the "geometry" of a unit pumper and is a true measure of the torque factors.
3. It would be physically impossible to have a unit with perfect mechanical advantage, or "geometry." The sampson post would have to be infinitely high to achieve this. As a practical matter, torque factors resulting in a multiplication of force of from 106 to 108 percent from the polished rod to the wrist pin are as good as can be hoped for in a unit pumper that is reasonable in price. Efficiency is compromised with cost to give the most economical result.
4. Other factors that help or hinder "geometry" are the location of the equalizer relative to the center iron, location of the wrist pin relative to the equalizer, etc.
5. Any unit pumper not having equal centers (that is, having the well end of the beam longer than the unit end) will have poorer torque factors and efficiency, since the unit pumper is basically a series of lever arms and pivots resulting in multiplication of force.

API TORQUE FACTORS

The API definition of torque factor is:

$$\text{Torque Factor} = \text{T/W}$$

where T is the torque at the low-speed shaft, and
W is the weight at the polished rod.

Actually, in this form, the relationship does not provide an immediate means for comparison of efficiency of various units. If the relationship were to be considered as a percentage of force multiplication from the polished rod to the wrist pin, it would provide an easily used criterion for comparison of efficiency. In order to state API torque factors in percentage form, the above relationship is divided by S/2 (the length of the lever arm from the wrist pin to the center of the low-speed shaft) and multiplied by 100.

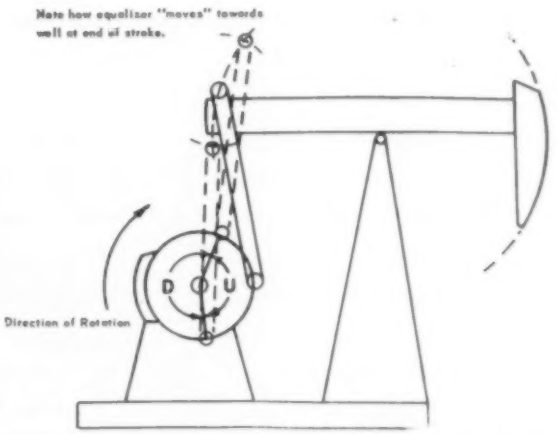

FIG. 3. Unit pumper diagram illustrates "geometry" of a typical unit. The circle of rotation of the center of the wrist pin about the center of the low-speed shaft measures the crank angle, Θ. It can be seen that the amount of crank angle consumed by the downstroke (D) is approximately 190 deg, whereas the upstroke consumes only approximately 170 deg. Crank angle Θ is always measured clockwise from the 12 o'clock position of the crank.

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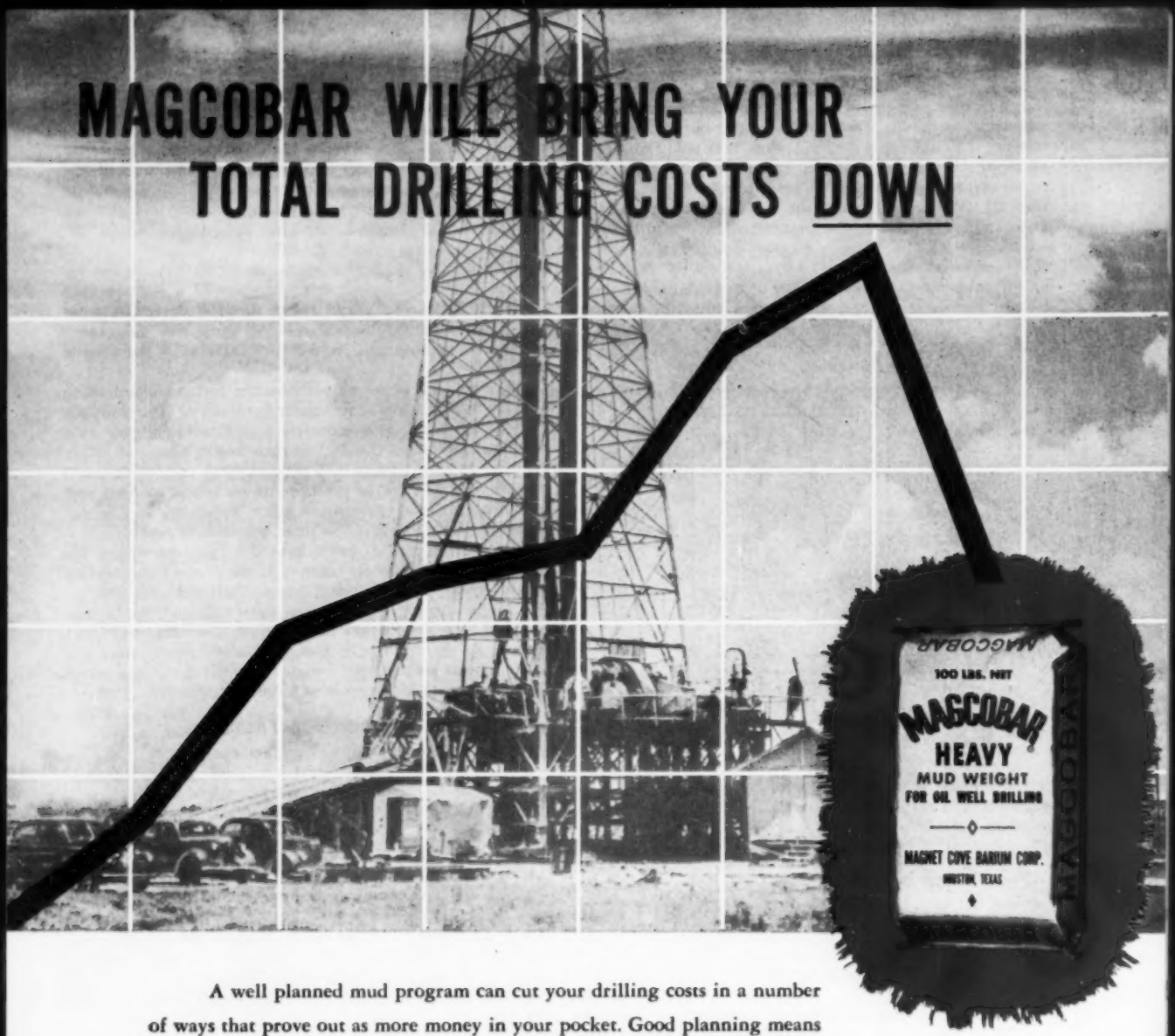

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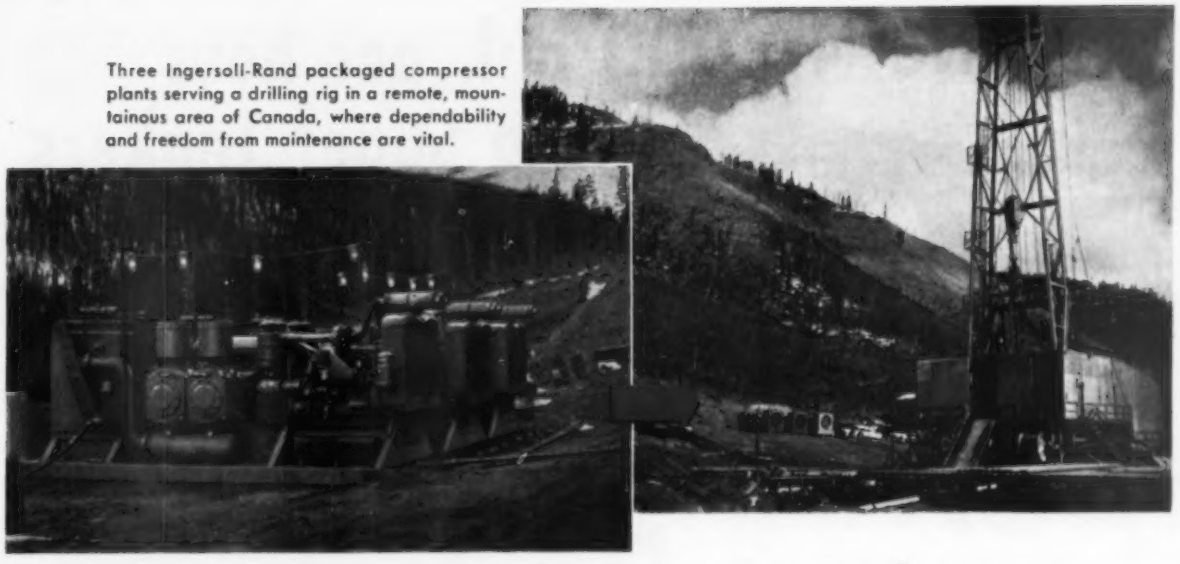

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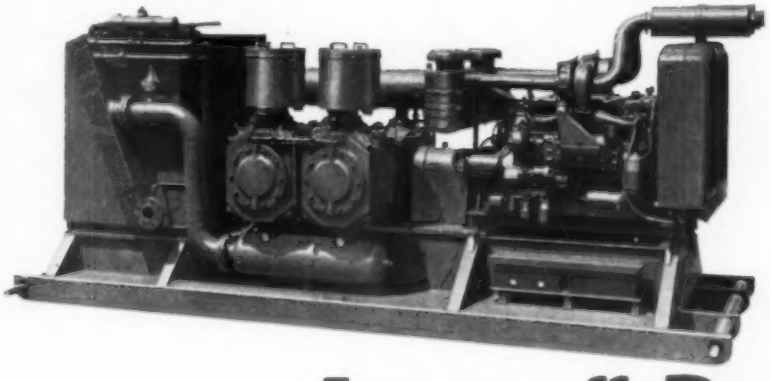

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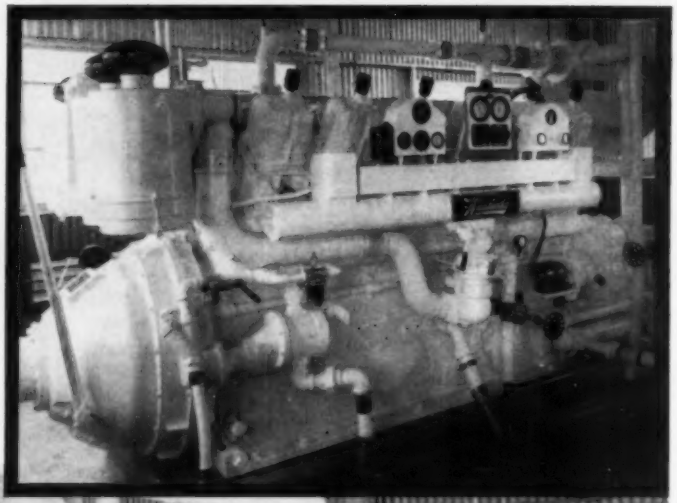

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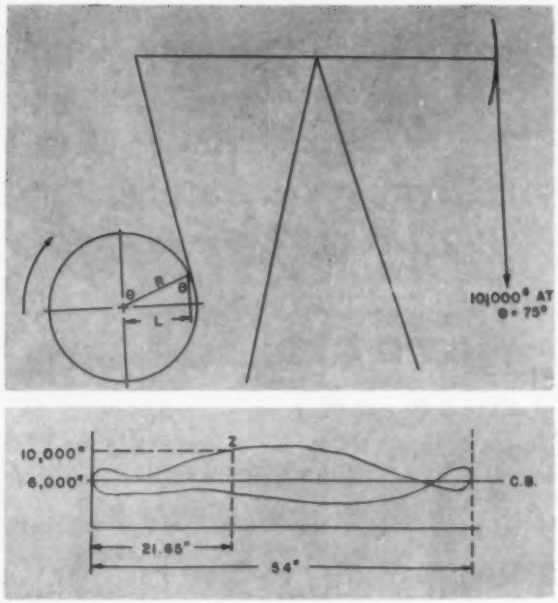

FIG. 4. Dynamometer card (below) is used to determine torque developed at gear reducer in unit pumper (above). If counterbalance is measured at $\Theta = 90$ deg, then counterbalance effect at any other angle varies directly as the sine of the angle, or or as R/L. A point on the dynamometer card (Z) is determined by multiplying the length of stroke (54 in.) by a rod-position factor (0.4015) found in Table 1, for a certain angle, Θ (75 deg).

COMPUTING TORQUE FROM DYNAMOMETER CARDS

The dynamometer has proved to be a very handy tool for determining torque characteristics of a unit pumper. In this discussion, it will be considered that a dynamometer card has been taken on an XYZ "114" unit. It will be assumed that the unit is running in a clockwise direction and that the counterbalance has been correctly measured at $\Theta = 90$ deg, Θ being the crank angle measured on the right side of the unit from the 12 o'clock position of the crank arm. (The correct procedure for measuring counterbalance with a dynamometer is presented diagrammatically in Fig. 8 and 9.)

It must be remembered that the dynamometer is at the polished rod, and measures both travel and weight at this point. The job of relating the loads measured at the polished rod to torque at the gear reducer would be complicated indeed if the angles involved had to be laid out each time and for the infinite positions of the polished rod. Instead, the API factors furnished by the unit manufacturer present much of the computation already done. A typical specimen of torque factors is presented in Table 1 as XYZ "114" unit pumper torque factors.

Fig. 4 gives a diagrammatic illustration of the factors involved and a hypothetical card for a rotary-balanced XYZ "114" unit. In this illustration, the crank angle Θ is 75 deg and the procedure for determining the torque at this angle is as follows:

Step 1. From Table 1, it is noted that the position of the rods at $\Theta = 75$ deg (assuming a 54-in. stroke) is 0.4015, meaning that 40.15 percent of the 54-in. stroke has been consumed at this point.

Step 2. Multiplying 0.4015 by 54 in. gives 21.65 in. This distance is measured on a horizontal line from the left limit of the card and identifies point Z on the dynamometer card, or the point where $\Theta = 75$ deg.

Step 3. Referring again to Table 1, it is seen that the torque factor for a 75-deg crank angle is 29.97 in.

Step 4. Assuming that the load at the polished rod is 10,000 lb, the gross torque at Z, neglecting counterbalance, is the product of the polished rod load and the torque factor: Gross Torque = 29.97 in × 10,000 lb = 299,700 in.-lb.

Step 5. However, the counterbalance offsets some of the load. This was measured at its maximum magnitude ($\Theta = 90$ deg) as 6000 lb at the polished rod, and includes all counterbalance effect. Obviously, however, most of the counterbalance is at the crank, requiring that the "geometry" of the unit be considered in order to relate it to its actual location and force. Therefore, the 6000-lb load must be multiplied by the API torque factor for $\Theta = 90$ deg to determine the counterbalance at the low-speed shaft at the point where the counterbalance was measured. Torque factor for $\Theta = 90$ deg is 28.62 in. Thus, the counterbalance torque is 28.62 in. × 6000 lb = 171,720 in.-lb.

But, the crank angle at Z is not 90 deg, but rather is 75 deg. Referring to Fig. 4, it is seen that the effective lever arm of the CB relative to the wrist pin and the low-speed shaft is L, rather than R. Thus, the relative effectiveness of counterbalance at 75 deg is proportional to L/R, or to the sine of 75 deg:

$$\text{Effective Counterbalance at Point Z} = 171{,}720 \text{ in.-lb.} \times \sin 75 \text{ deg} = 165{,}870 \text{ in.-lb}$$

Step 6. Therefore, the net or actual torque at the center of the low-speed shaft at Z is the difference between the torque developed by the polished rod load and the torque due to the counterbalance, or:

$$\text{Net Torque at Point X} = 299{,}700 \text{ in.-lb} - 165{,}870 \text{ in.-lb} = 133{,}830 \text{ in.-lb}$$

UNIT UNBALANCE

The unbalance of the unit is the difference in the weight of the pitmans, equalizer, wrist pins, etc. compared to the weight of the horse's head and hanger. Compared to the rotary counterbalance effect, the unit unbalance usually has a very minor effect. To consider it as part of the rotary effect and to consider it to go to zero effect at crank angles of 0 to 180 deg (approximately) is technically wrong, but to do so introduces very little error. In addition, maximum torque nearly always occurs where the rotary counterbalance is more than 60 percent effective, so the error grows

TABLE 1. API Torque Factors for 114,000 in.-lb Unit Pumper — XYZ Corporation.

Position of crank -deg	Position of rods, Length of stroke 34"	44"	54"	Torque factor, Length of stroke 34"	44"	54"
0	.0035	.0055	.0066	−2.38	−3.63	−5.40
15	.0035	.0081	.0044	3.06	4.07	4.32
30	.0526	.0406	.0395	10.89	11.44	14.31
45	.126	.13	.1381	13.00	17.82	22.68
60	.242	.252	.2585	16.32	22.0	28.08
75	.369	.382	.4015	17.935	23.76	29.97
90	.505	.52	.541	17.85	23.32	28.62
105	.642	.66	.669	16.49	21.01	25.38
120	.76	.765	.777	14.28	17.82	21.06
135	.854	.86	.869	11.39	14.08	16.20
150	.927	.935	.935	8.16	9.90	11.61
165	.98	.976	.952	4.675	5.72	6.75
180	1.00	1.00	.998	1.02	1.21	1.62
195	.99	.993	.968	−2.72	−3.30	−3.51
210	.958	.968	.964	−6.29	−7.81	−8.91
225	.896	.912	.908	−9.69	−12.10	−14.31
240	.812	.828	.834	−12.75	−16.06	−19.17
255	.706	.725	.675	−15.045	−19.14	−23.22
270	.59	.602	.614	−16.66	−21.23	−25.92
285	.453	.48	.485	−17.0	−22.0	−27.00
300	.326	.35	.358	−16.49	−21.45	−26.46
315	.21	.228	.237	−14.62	−19.36	−24.30
330	.116	.125	.153	−11.56	−15.62	−19.98
345	.042	.046	.048	−7.48	−10.23	−13.77

Position of crank is the angular displacement measured clockwise from the 12 o'clock position viewed with the well head on the right. Position is expressed as a fraction of stroke above lowermost position. Torque factor = $\frac{T}{W}$, where T is torque on pumping unit reducer due to polished rod load W.

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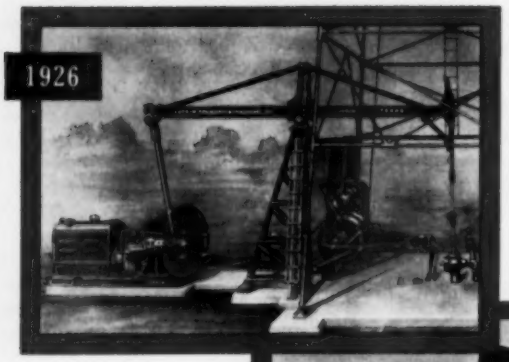

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smaller where it might make any appreciable difference. Also, additional counterbalance effect is gained due to the flywheel effect of the rotary counterbalance when it slows at points of peak torque.

Due to the probable limits of error using our present dynamometers (measurement of time versus distance, of velocity, of acceleration, and of inertia), calculation of flywheel effect would be subject to so much error as to render it valueless. The magnitude of the effect is virtually impossible to measure from a dynamometer card.

Offsetting the flywheel effect is friction torque in the unit pumper. There is no practical means of measuring friction torque, but it must be considerable and probably results in a considerable resultant torque in the low-speed shaft. Thus friction torque probably more than offsets inertia gains in rotary counterbalance.

PEAK TORQUE DETERMINATION

It is obvious that, in order to determine the torque throughout the entire pumping cycle, it will be necessary to repeat the procedure outlined above for the many positions of the crank. The maximum torque encountered will be the peak torque. However, it is also quite obvious that twice during the cycle, the torque goes to zero, occurring when the pitman and the crank are in a straight line. Actually, it is seen from inspecting the torque factors and considering that the peak load on the upstroke and minimum load on the downstroke are usually found in the middle portion of the card, that peak torque on the upstroke will usually be found between 45 and 120 deg, and on the downstroke between 240 and 330 deg.

After practice, one can inspect the card and select the probable point of peak torque on the upstroke and the downstroke. Checking these two points and four other points (one each on both "sides" of the point selected on the upstroke and on the downstroke) will determine the peak torque, computing only six points instead of 24.

One could graphically plot counterbalance and gross torque curves, subtract the curves graphically, and end up with a net torque curve. However, this requires a considerable amount of time and is not necessary. In order to present a complete example of both algebraic and graphic determinations, Fig. 5, 6, 7, and Table 2 follow through a given example and include a determination of best counterbalance. Unit involved is an XYZ "114" and the figures in Table 1 apply to this example.

BEST COUNTERBALANCE

The old maxim that the best counterbalance is obtained by dividing the card with the counterbalance line is not true. The effective counterbalance is not a straight line but is approximately as represented in Fig. 5 relative to the dynamometer (which is at the polished rod).

The best counterbalance for both the prime mover and the gear reducer is that counterbalance which results in equal torque peaks in the upstroke and downstroke. This

TABLE 2.

				Gross torque			Graph VII counterbalance measured 6400# @ ° = 90° at P. R.			Net torque on reducer in.-lb	Best CB	Net in.-lb torque on reducer	
(1)		(2) x (3) = (4)		(5) x (6) = (7)			(8) x (9) = (10)			(7)–(10)	(11)	(7)–(11)	
Crank position ° in degrees	Position of rods @54 in. stroke (from Mfgrs tables)	Length of stroke @polish rod, in.	Position of letter symbols on dynagraph measured from left limit of graph (see dynagraph), in.	Weight measured from dynagraph at various positions in lb	Torque factors @ 54 in. stroke (from mfgrs tables)	Gross torque on gear reducer (neglecting CB) in in.-lb	CB effect measured @ polish rod @ ° = 90° = 6400# therefore CB effect @ center L.S. shaft = (6400 x (28.62) = 183,170 in.-lb @ ° = 90° NOTE: 28.62 = T.F. ° = 90°	Sine °	CB torque @ various positions in in.-lb	Actual torque under measured conditions	CB @ P.R. = 7850# (See text for how arrived at) so 7850 x 28.62 = 224,650 in.-lb @ ° = 90° CB torque @ various positions (224,650) x (10)	Torque on reducer if best CB (see 12) were used	% multiplication of W from polished rod to wrist pin rel. to L.S. shaft (T.F. +8/2) (100)
0	.0066	54	.36	6950	— 5.40	— 37,550	183,170 in.-lb	—0—	—0—	—37550	—0—	—37550	20
15	.0044	54	.24	7050	4.32	30,450	183,170 in.-lb	.25882	—47400	—16950	58150	—27700	16
30	.0395	54	2.13	8100	14.31	115,900	183,170 in.-lb	.50000	91600	24300	112300	3600	53
45	.1381	54	7.46	8500	22.68	192,800	183,170 in.-lb	.70711	129500	63300	158850	33950	84
60	.2585	54	13.96	10600	28.08	297,650	183,170 in.-lb	.86603	158650	139000	194550	103100	104
75	.4015	54	21.68	11900	29.97	356,650	183,170 in.-lb	.96593	176950	179700	217000	139650	111
90	.541	54	29.21	9900	28.62	283,350	183,170 in.-lb	1.00000	183150	100200	224650	58700	106
105	.669	54	36.13	7350	25.38	186,550	183,170 in.-lb	.96593	176950	9600	217000	—30450	84
120	.777	54	41.96	6250	21.06	131,600	183,170 in.-lb	.86603	158650	—27050	194550	—62950	78
135	.869	54	46.93	6200	16.20	100,450	183,170 in.-lb	.70711	129500	—29050	158850	—58400	60
150	.935	54	50.49	6200	11.61	72,000	183,170 in.-lb	.50000	91600	—19600	112300	—40000	43
165	.952	54	51.41	6250	6.75	42,200	183,170 in.-lb	.25882	47400	—5200	58150	—15950	25
180	.908	54	53.89	6200	1.62	10,045	183,170 in.-lb	—0—	—0—	10450	—0—	10450	6
195	.968	54	52.27	4000	—3.51	—14,050	183,170 in.-lb	—.25882	—47400	33350	—58150	44100	13
210	.964	54	52.06	3950	—8.91	—35,200	183,170 in.-lb	—.50000	—91600	56400	—112300	77100	33
225	.908	54	49.03	3900	—14.31	—55,800	183,170 in.-lb	—.70711	—129500	73700	—158850	103050	53
240	.834	54	45.04	2950	—19.17	—56,550	183,170 in.-lb	—.86603	—158650	102100	—194550	138000	71
255	.675	54	36.45	4300	—23.22	—99,850	183,170 in.-lb	—.96593	—176950	77100	—217000	117150	86
270	.614	54	33.16	4500	—25.92	—116,650	183,170 in.-lb	—1.00000	—183150	66500	—224650	108000	96
285	.485	54	26.19	4950	—27.00	—133,650	183,170 in.-lb	—.96593	—176950	43300	—217000	83350	100
300	.358	54	19.33	5850	—26.46	—154,800	183,170 in.-lb	—.86603	—158650	3850	—194550	39750	98
315	.237	54	12.80	5800	—24.30	—140,950	183,170 in.-lb	—.70711	—129500	—11450	—158850	17900	90
330	.153	54	8.26	5650	—19.98	—112,900	183,170 in.-lb	—.50000	—91600	—21300	—112300	—600	54
345	.048	54	2.59	6200	—13.77	—85,350	183,170 in.-lb	—.25882	—47400	—37950	—58150	—27200	51
360	0066	54	.36	6950	—5.40	—37 ,550	183,170 in.-lb	—0—	—0—	—37550	—0—	—37550	20

FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

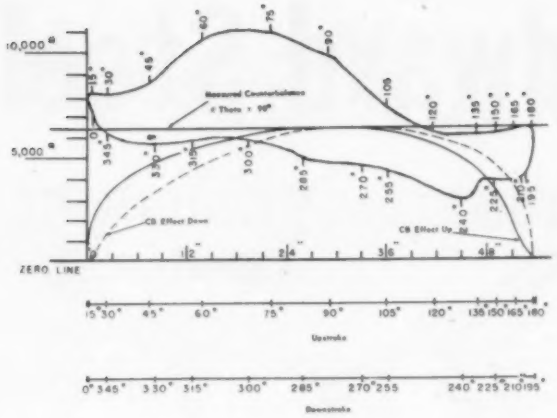


FIG. 5. Counterbalance effect on upstroke and downstroke is drawn in on a typical dynamometer card which has been graduated in 15-deg intervals through a complete pumping cycle.

can mean monthly savings to producers using electric motors since the peak current is directly proportional to peak torque, and RMS rates exact penalties for high (disaproportionate up and down) peaks. Correct counterbalance is easily determined in electric motor installations using an ammeter, since peak amperage is directly proportional to shaft torque demands.

To determine that counterbalance which results in equal torque on the upstroke and downstroke, the following procedure may be applied:

After weighing card and determining present torque peaks up and down, subtract peak torque down from peak torque up. (In the previous example: 179,700 in.-lb − 102,100 in.-lb = 77,600 in.-lb). Divide this difference by S/2. (77,600 in.-lb ÷ 27 in. = 2875 lb). This quotient is the net discrepancy at the wrist pin. Divide this by 2. (2875 lb ÷ 2 = 1438 lb). Add this quotient to the present counterbalance and the best counterbalance will be determined.

Also note that the example sites an under-counterbalanced situation. However, the procedure is also correct for over-counterbalanced units since the first subtraction would result in a negative value, which when added to the present counterbalance would result in reducing the value.

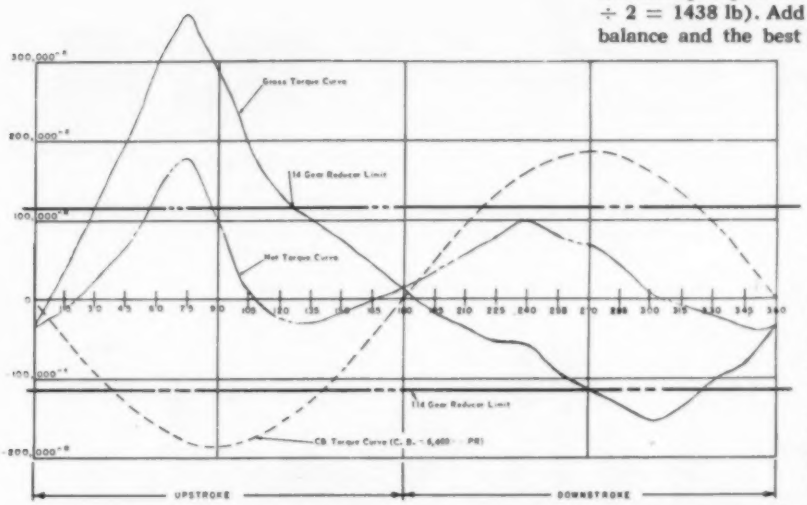


FIG. 6. Net torque at the gear reducer can be determined by graphically subtracting the counterbalance torque curve from the gross torque curve. Note that net torque in this example peaks on the upstroke at a value greater than the limit of the 144,000 in.-lb gear reducer.

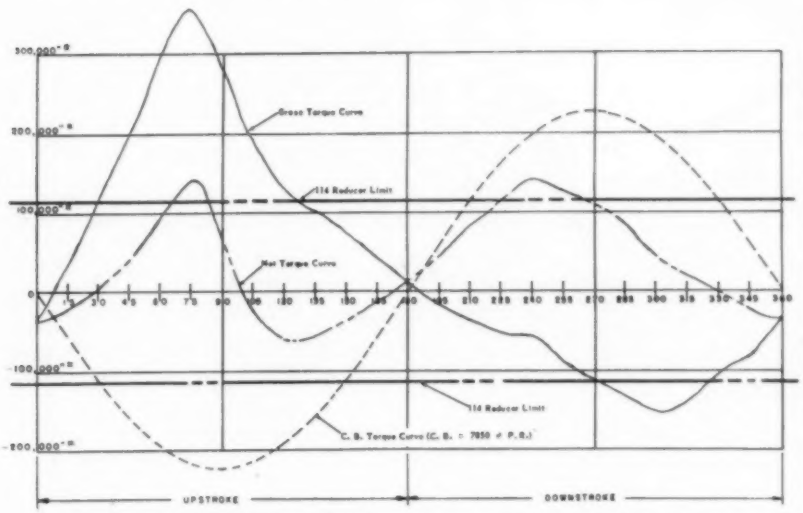
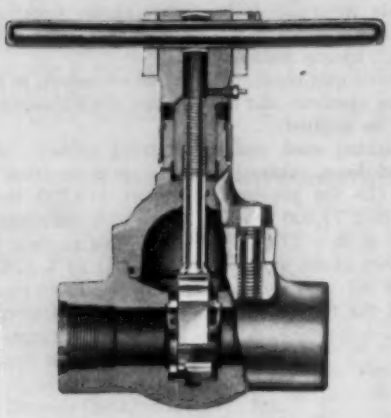


FIG. 7. Increased counterbalance with the same gross torque curve as shown in Fig. 6 results in lowering the peak net torque on the upstroke, increasing the peak net torque on the downstroke, and giving more nearly equal peaks of net torque throughout the cycle.

In wells producing much gas, cards taken at various times will reflect greatly different loadings. Similarly, wells that are pumped off will reflect different loadings as the well is pumped down. The best counterbalance to use in such cases is an average that allows torques to be approximately the same under the varying conditions. However, unit pumpers on wells such as these are seldom overloaded, but if so, the pumping cycle can be altered to prevent this. Wells which have continuously overloaded unit pumpers are usually those wells which have a water cut of 80 percent or more (high fluid volume) or which do not have the benefit of boost (gas or fluid level) at the bottom of the hole. Wells of this nature are usually pumped around the clock.

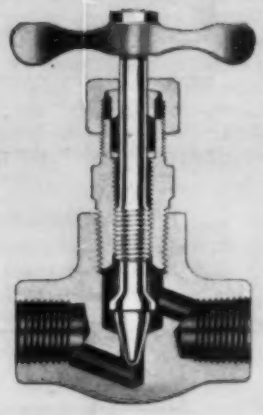
To go to the trouble of counterbalancing wells of this nature is good operating practice since good counterbalance can often mean the difference between enormous overloads and loads that do not exceed the gear reducer's rating. Even if the reducer is overloaded at best counterbalance, this fact is known and continued pumping is a known and calculated risk. It is well to remember that the gear reducer is the single most expensive part of

Rockwell-Built Edward Steel

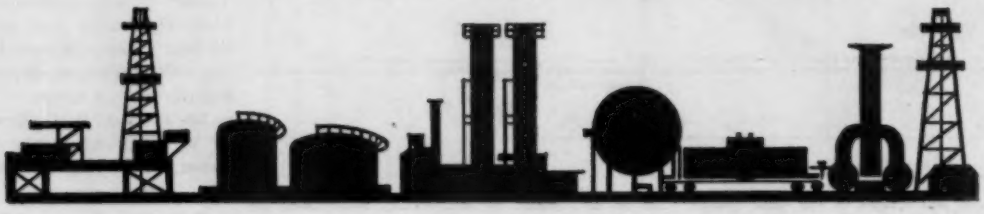


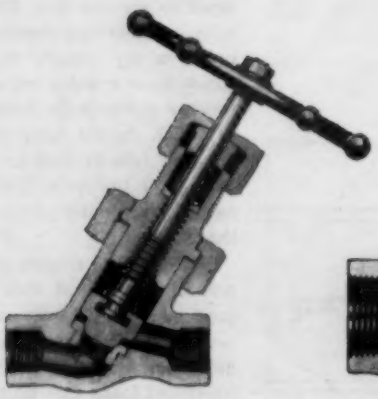
MUDWONDER MUDLINE VALVES
Figs. 2128-3128
For pressures to 2,000-3,000 lb WOG
Bolted bonnets, screwed or flanged ends

GLOBE STOP VALVE
Fig. 158
For pressures to 10,000 lb WOG
Screwed bonnet, screwed or socket welding ends

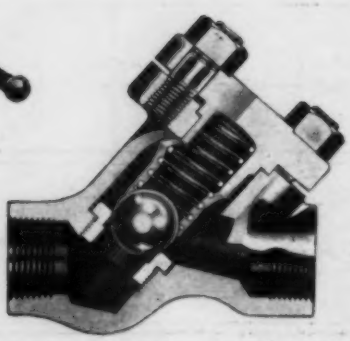


GLOBE GAGE VALVE
Fig. 152
For pressures to 4,000 lb WOG
Screwed or union bonnet, screwed ends

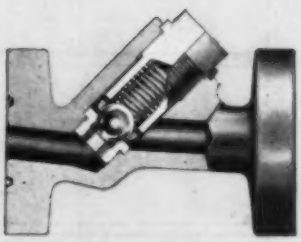




GLOBE STOP VALVE
Fig. 2698
For pressures to 2,000 lb WOG
Union bonnet, screwed or socket welding ends



BALL CHECK VALVE
Fig. 4632
For steam pressures to 600 lb A.S.A. (2,000 lb WOG)
Horizontal or vertical
Bolted cover, screwed or socket welding ends



BALL CHECK VALVES
Figs. 5160-9160
For pressures to 5,000-10,000 lb WOG
Horizontal or vertical, screwed covers, flanged ends

Valves Work Everywhere

in drilling...production...refining...

Edward valves are on the job, no matter where you look. From the towering derricks of Northern Alberta to offshore rigs on the Gulf . . . from refineries on the Jersey Flats to California natural gas plants . . . the word is—"You buy a better valve from Edward!"

Edward Globe Valves

Bodies are drop-forged steel, for greater strength and resistance to erosion. Large-diameter handwheels permit operation without a wrench or cheater; cross-arm Impactor* handle for quick, tight closing is standard on 2" Fig. 158. Figures 158 and 2698 have replaceable seats. Disks—both plug and needle types—are carefully aligned, and seats are lapped for tight sealing. Stems are EValloy,* an exclusive Edward stainless steel, centerless ground to a fine finish. Carefully machined Acme stem threads assure easy operation. Bonnet threads plated by an exclusive EValizing* process for maximum resistance to wear and corrosion. Deep stuffing boxes, with exclusive EValpak* asbestos-graphite packing, assure a tight seal with minimum resistance to stem turning.

Edward Ball Check Valves

Identical to Edward globe stop valves in body and seat features. Rolled steel bonnet with integral ribs to guide ball accurately. Ball is corrosion-resistant high carbon stainless steel, precision-ground for tight seating. High carbon stainless steel spring gives positive aid in seating ball.

Edward Mudwonder Valves

Body and bonnet are high-strength alloy steel with heavy body-bonnet cover flanges. Accurately machined to assure drop-tight sealing under extreme pressures. Double-threaded yoke bushing, completely enclosed, gives 2-to-1 ratio. Corrosion-resistant stainless steel stem with slotted gate coupling to eliminate bending or binding. Gate is hard chrome plated to reduce friction, resist erosion and abrasion. Seat insert of resilient buna–N synthetic rubber, molded integrally over steel wear rings. Seat and gate easily replaced without removing Mudwonder* from line.

WHERE CAN YOU USE EDWARD VALVES?

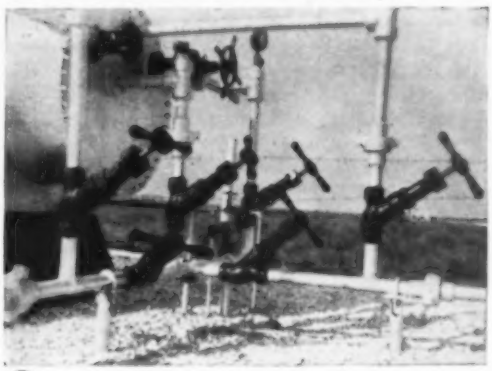
Our customers report complete satisfaction in the use of Edward valves for water flood service . . . throttling . . . on high-pressure heaters, treaters and separators . . . on pressure vessel controls . . . on headers and flow lines to heaters and exchangers . . . for manifold service . . . in gasoline or gas sulfur extraction plants . . . for "unloading" valves at gas compressor stations . . . and in many other applications. You name your need . . . let your Edward representative show how to fulfill it with versatile, economical, completely dependable Edward valves. They are available from your favorite oil field supply store, from your industrial distributor, or direct from *Edward Valves, Inc., 1200 W. 145th Street, East Chicago, Indiana* (Subsidiary of Rockwell Manufacturing Company). Represented in Canada by Lytle Engineering Specialties, Ltd., Montreal, and Rotary Sales & Service, Ltd., Edmonton.

EDWARD STEEL VALVES

another fine product by

ROCKWELL

Edward builds a complete line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressures up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets; with screwed, welding or flanged ends. *T.M. Reg. U.S. Pat. Off.



Edward 2" Fig. 158 valves in service on heater by-pass lines in Louisiana oil fields. Note Impactor handles for quick, easy closing against high pressures.

Fig. 2698 valves on cooling coils of natural gas cooler. Scene: New Mexico field processing plant. Lubricated plug valves in photo are Rockwell-Nordstrom.

Forty-two Edward forged steel globe valves (Fig. 2698) throttle the flow on this West Texas water flood. Owner reports absolutely no maintenance costs in two years (over 4,000,000 barrels of water)!

the unit pumper. If it is destroyed, repairs can well amount to half or more of the cost of a new unit pumper.

All of the previous discussion has been concerned with rotary-balanced units, and with the unit running in a clockwise direction. If the unit is run "backwards" (counterclockwise), the upstroke consumes more of the crank angle than does the downstroke and torque factors are in reverse order (and opposite in sign) to those indicated in the torque tables. If the unit is beam balanced, the counterbalance measured at $\Theta = 90$ deg is for all practical purposes that for the whole cycle, and net torque can be measured easily by first subtracting $W - CB$, then considering the torque factors of the unit for net torque. While this is not exactly true (since inertia results in increasing and lessening of the CB effect due to positive and negative acceleration), the velocity is most nearly constant during that part of the cycle (middle 60 percent of the card) in which peak torque is usually experienced. Beam-balanced and units running counter-clockwise have been only briefly covered since most of the larger units presently being sold are rotary balanced units, and most of these are run in a clockwise direction.

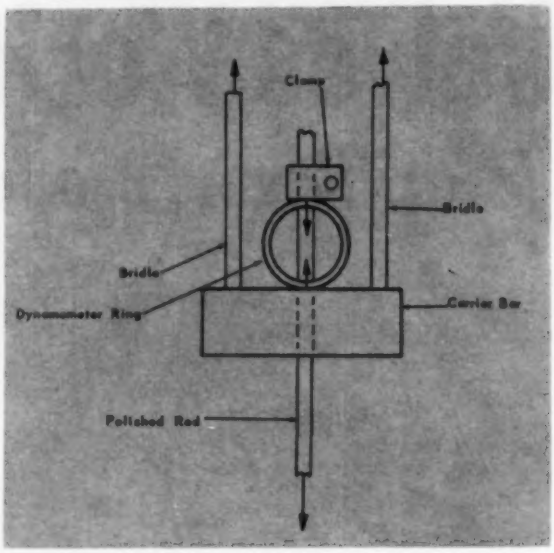


FIG. 9. Ring dynamometer under actual conditions encountered when weighing well. Dynamometer ring is in compression and weighs the load by marking deflection of the ring on a graph.

If a partially beam-balanced, partially rotary-balanced unit is weighed, the only practical thing that can be done is to take the manufacturer's CB effect tables for the beam weights involved from both the polished rod load and the measured counterbalance, and then treat the remainder as though it were a straight rotary-balanced unit.

To assume that the counterbalance effect in actuality is that which the manufacturer indicates in his published tables at the various "settings" could in some cases introduce considerable error. One reason for this is that crank weights are castings and manufacturing tolerances must allow for a considerable plus or minus discrepancy for shrinkage. Some manufacturers may give tables for the average tolerance, some for the minimum, and some for the maximum.

Also, some manufacturers give counterbalance effect at the wrist pin (where it actually is and where it is a maximum as compared to effect at the polished rod) and some give it at the polished rod.

Thus, it is felt that it is best to weigh the counterbalance and to check the tables provided (considering the location quoted for the effect). If the two nearly coincide, then it will be easy to spot the weights to any counterbalance desired. If there is a considerable difference, then trial and error is necessary to get the counterbalance setting determined best.

The field engineer must take full advantage of the information available to him. If this is done, and if the ring dynmometer is put to its best use, many thousands of dollars can be saved by the industry by preventing gear reducer failure.

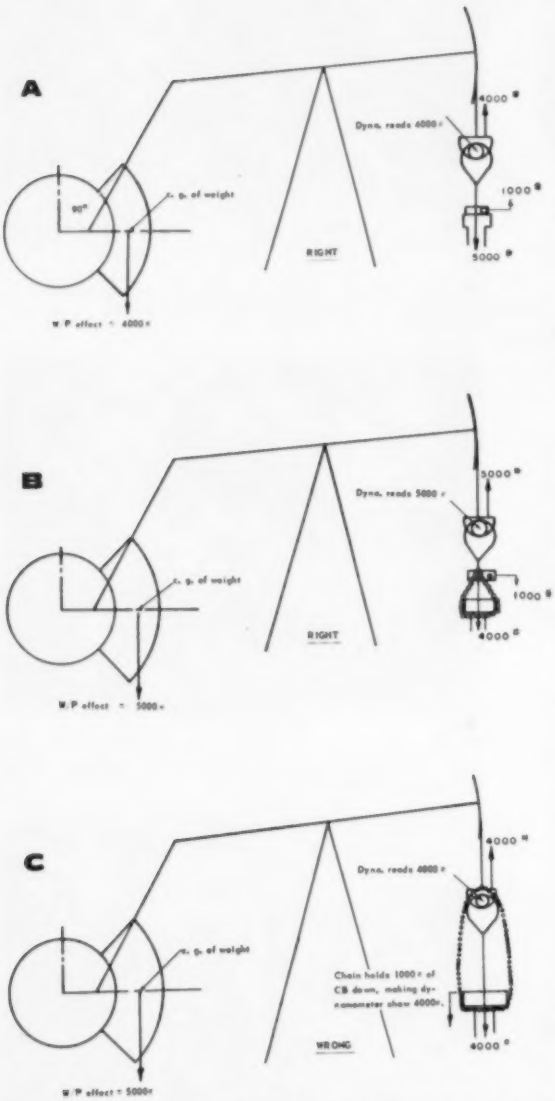


FIG. 8. Correct procedure for measuring counterbalance with a ring dynamometer is illustrated. Counterbalance should always be at $\Theta = 90$ deg. (A) If the load at the polished rod is heavier than the counterbalance, clamp the polished rod at the stuffing box. Draw counterbalance line. (B) If counterbalance is heavier than polished rod load, install clamp below carrier bar and chain to stuffing box. Draw counterbalance line. (C) Chaining carrier bar to stuffing box will result in error since the dynamometer will record polished rod load and not counterbalance.

with screwed, welding or flanged ends. *T.M. Reg. U.S. Pat. Off.
barrels of water)!

AAODC Hears Atwood on Alaska

Contractors Discuss Economics, Blowouts, Air Drilling

J. U. Teague

Pierre Rinfret

ROBERT BRUCE ATWOOD, a leader in the campaign for Alaska statehood will be the principal banquet speaker at the American Association of Oilwell Drilling Contractors' 18th Annual Meeting in Dallas, Texas, October 1-3.

Atwood, chairman of the Alaska Statehood Committee and editor and publisher of the *Anchorage Daily Times*, will tell the national gathering of contractors about the 49th state. A former president of the Anchorage Chamber of Commerce, Atwood is the author of many pamphlets, articles and editorials published in Alaska and reprinted in various journals in the United States. Before making his home in Alaska, he was a reporter for the Worchester, Massachusetts, *Telegram* and the *Illinois State Journal*. In addition to his newspaper enterprise, Atwood is also president of the Anchorage Hotel, and a member of the U. S. Surgeon General's Advisory Committee.

Economists, Engineers

Economists and engineers will discuss financial and technical phases of the oil business at the three general sessions to take place in the Adolphus and Baker hotels.

Thursday afternoon in the Adolphus Crystal Ballroom, the drilling contractors will hear an address by national AAODC President J. U. Teague, president of Columbia Drilling Company, Houston.

Before his election as president at the last general convention, Teague was national vice president of the drilling association. He has been active in AAODC work more than a decade, and had previously served as chairman of the Rotary Drilling Committee for three years, chairman of the Houston Chapter, vice president of the Gulf Coast area, and a director. He organized Columbia Drilling in 1949.

Dr. Pierre Rinfret, nationally-known economist, will speak on "The Oil Industry—Forecast of Economic Conditions and Capital Expenditures." Dr. Rinfret is vice president and director of the Economic Department of Lionel D. Edie & Company, Inc., New York economic consulting and investment advisory concern. Dr. Rinfret co-authors with Dr. Edie the series of 10 regular monthly economic studies prepared for various business, banking and individual clients.

Dr. Rinfret holds a BS in finance and economics and master of business administration degrees from New York University. As a Fulbright Fellow, he received the Doctor of Political Economy with honors from the University of Dijon, France, in 1950. He continued his studies with post-doctorial work in economic theory at Columbia University. From 1952 to 1956, he completed PhD course requirements in business administration at New York University, and was a lecturer in economic theory and the history of economic thought in the graduate school.

William P. Clements, Jr., president of Southeastern Drilling Corporation, Dallas, will preside at the Thursday afternoon meeting.

Friday morning's session in the Terrace Room of the Baker Hotel will include a four-part panel discussion of "Things to Come in Drilling and Production." The speakers, all staff members of *The Oil and Gas Journal*, are K. B. Barnes, editorial director; John C. Casper, economics editor, and Dr. Frank J. Gardner, exploration editor, and Ed McGhee, drilling editor. H. W. Davidson, Davidson Drilling Company, Midland, Texas, will be chairman.

The final general session, Friday afternoon in the Terrace Room of the Baker, will be devoted to drilling technology. M. G. Rowe, president of Rowan Drilling Company, Inc., Fort Worth, and program chairman of the AAODC annual meeting, will preside.

E. Dale Mount, general chairman, will preside at the banquet Friday evening, October 3, which concludes the meeting. The banquet will be held in the Grand Ballroom of the Adolphus Hotel.

Blowouts, Air Drilling

Oil well blowouts will be the subject of two sections of the three-part program Friday afternoon. First speaker is Frank J. Whitley, BBM Drilling Company, Houston, who will review the new AAODC-American Petroleum Institute training program on "Prevention and Control of Blowouts." He will show the two motion pictures developed for the course by the Petroleum Extension Service of the University of Texas.

"Development of Blowout Control Devices" will be discussed in a paper co-authored by J. E. Ortloff of Jersey Production Research Company, Tulsa, and W. E. Harrelson, Creole Petroleum Company, Tia Juana, Venezuela.

In the final technical report, a trio of research engineers will talk about a problem of drilling with air or gas. J. L. Lummus, B. V. Randall and R. P. Vincent will present a paper on "Combating Wet Formations While Drilling with Air or Gas." All are members of Pan American Petroleum Corporation's Research Department in Tulsa.

Committee Meetings

The 14 AAODC standing committees will meet at 9:30 Thursday morning. Directors' meetings are scheduled for 2 p.m. Wednesday and 4 p.m. Thursday. Incoming AAODC officials, who will take office January 1, 1959, will be introduced at the luncheon Friday.

Special arrangements for entertainment of the ladies accompanying their husbands to the meeting have been made by a committee headed by Mrs. E. Dale Mount. A style show and luncheon are planned at noon Thursday at the Dallas Country Club, and a hospitality suite will be maintained at the Baker Hotel throughout the meeting. ★ ★ ★

There Is Absolutely NO CARROT in the new WELEX

SUPER DYNA-JET*

This is no idle claim. *There is only one shaped charge perforator available in the oil field that absolutely will not produce a carrot.* That charge is the new Welex Super Dyna-Jet. Utilizing many of the principles of the original Dyna-Jet perforator, which introduced a new concept of perforating, the Super Dyna-Jet is another forward step by the company that brought you the first shaped charge perforator.

Added to the impossibility of carrot formation by the Welex Super Dyna-Jet is the advantage of greatly increased penetration, large entrance hole, greater hole volume and tremendously increased flow index.

The Welex Super Dyna-Jet was created for one purpose: to completely eliminate the possibility of forming a carrot which could plug a perforation and retard flow. In addition to being a completely carrot-free perforator, the Welex Super Dyna-Jet produces less burr than is possible with other shaped charges. The average burr height after perforating with the Super Dyna-Jet is 0.03", virtually no burr at all.

Performance-wise, the Welex Super-Dyna Jet leads the field by a wide margin. Shooting into 16-day neat cement faced with a mild steel plate and through one-half inch of water, the following performance data was obtained:

Penetration Depth	13.28"
Entrance Hole	0.48"
Hole Volume	30.00cc
Burr Height	0.03"

Available in 3⅜", 4" and 5" hollow carrier guns, the Welex Super-Dyna Jet means more production every time.

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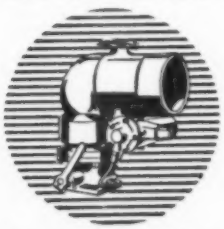
Worlds' Deepest Well

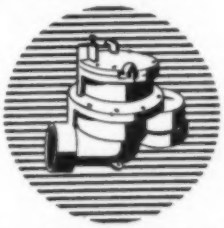
Monstrous power of these triple LeRoi gas engines pushed the Phillips well 1-EE University, Pecos County, Texas, past the 24,000 foot mark, deepest hole in the world.

THIS IS GAS ENGINE POWER. Its unfailing dependability is, of course, taken for granted because good engine designers intended it that way. Likewise, dependable and unfailing as the gas engine carburetion must be, it, too, is taken for granted because carburetor designers at Ensign intended it that way. And so it is today for nearly half a century Ensign carburetion is OEM (original equipment) on practically all leading makes of Gas and LP-Gas power units. Ensign is dependable.

INSIST ON ENSIGN — ACCEPT NOTHING LESS!



Ensign 3" Model Dg Gas Carburetor



Ensign 2" Model B Fuel Regulator

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Here are several "rig-tested" . . .

DRILLING IDEAS at WORK

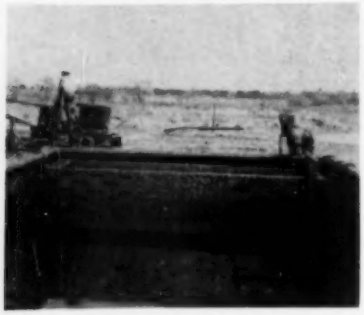
Table Simplifies Mud Mixing Job

● This table built next to the mud tanks makes it easy to unload the mud additives and just as easy to drop the contents of the sacks into the tanks. The table is built at truck height so that the sacks can be more easily unloaded from the truck. Hoppers are placed right in front of the sacks so that all that is required is to hoist the sacks and cut them over the hopper. The jet line around the top of the tanks provides primary mixing as the additives are carried into the tanks.

Junk Basket Strains Out Mud Line Returns

● On workover jobs where cement and iron are being drilled, a small compartment may be rigged up inside of the mud tank to catch the cuttings and to allow part of them to settle out before the mud returns to the tank. This saves frequent cleaning of the tank and provides a place for the rough cuttings to be caught during workover and fishing jobs.

The compartment is made of floor plate material and is made slightly shorter than the tank is wide. Straps



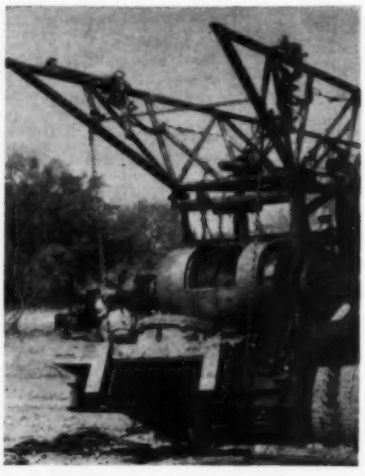
on the end are hooked over the sides of the tank so that the compartment can be set under the mud return line wherever it may happen to come back into the tank. Slots are cut along the sides so that the mud can run through, yet the larger pieces will be retained in the compartment.

Liquid Caustic Additive Saves Mixing on Rig

● A contractor operating in Louisiana has rigged up an elevated 85-bbl storage tank to hold liquid caustic for treating the drilling mud. Instead of a vat or drum to mix the caustic with steam or water, he merely mounts an open-topped drum at the tank. Small pieces of angle iron tack-welded inside the drum are located so that the space between each marker is equal to 25 lb of powdered caustic. The drum is filled from the elevated storage tank to the desired mark and the caustic solution is then fed into the mud mixing pit at the prescribed rate.

Rotary Table Hinged to Unit Facilitates Moving

● If the rotary table is built into the base of the drilling unit on a hinge, it can be easily swung up out of the way when the truck is driven over the road. When lowering the mast, a chain is thrown through the legs of the mast and looped around eyes in the side of the table. As the derrick comes down, the table is swung up enough to give clearance when passing over the road. Even the rotary chain is left intact and it tightens up again when the table is placed on the blocks at the new location.



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102

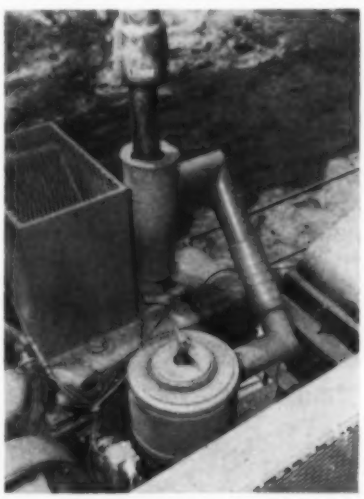
Ramp Quickly Fastened to Derrick Floor

● Here is an easy way to fasten the ramp into the side of the derrick floor. The two upper pieces are first bolted to the derrick floor and then the ramp is swung up to match the hanging pieces, which are bolted to the ramp. This makes a rigid support for the ramp, yet it is easily removed or replaced.

Exchanger On Exhaust Heats Intake Air

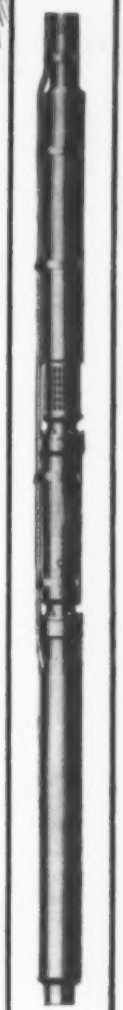
● Where engines operate in cold climates, a means of making them run more efficiently may be attained by installing a jacket around the exhaust pipe and running a piece of stove-pipe material to the air intake. This causes warm air to be drawn into the engine and increases the efficiency.

The jacket around the exhaust pipe is made from light-gage metal with an opening cut in the side to receive the



stove-pipe material. A plate is welded around the top to make the air come in close contact with the pipe, yet not have any restriction to the passage of air. The other end of the stove pipe is inserted in the side of the air cleaner with an asbestos flexible coupling in between to eliminate engine vibration shaking the components.

INCREASE PROFITS WITH REDA Submergible PUMPS



REDA GIVES YOU THESE COST SAVING FEATURES AND DOES THE JOB BETTER!

- **Lower cost for installation, operation and maintenance.**
- **250 to 18,000 BPD capacities**
- **Depths to 10,000 ft.**
- **Corrosion-resistant construction**
- **Long life — dependable service**
- **A complete line to meet pumping requirements**

and

INVESTMENT COST IS FAR LOWER WHEN YOU CHOOSE REDA FOR YOUR PUMPING NEEDS.

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SIGN OF QUALITY SUBMERGIBLE REDA PUMPS

REDA PUMP CO.
BARTLESVILLE, OKLAHOMA

Manufacturers of submergible motors and pumps for over 35 years — for oil, brine and water wells, gasoline and jet fuel —

What's doing in DRILLING

Drilling Resumed at World's Deepest Hole

Phillips Petroleum Company has resumed drilling operations at its No. 1-EE University, the world's deepest well located in Pecos County, Texas. Operations had been halted about a month at a depth of 24,357 ft to prepare new drill pipe suitable for the ultra-deep hole. Drilling was resumed on September 6.

At last report, on September 11, the No. 1-EE was drilling below 24,576 ft at a rate of 34 ft per day. The drilling string now consists of:

15 4¼-in. drill collars
284 jts 4-in. OD flush joint drill pipe
168 jts 3½-in. slim hole drill pipe
334 jts 3½-in. grade 43-40, 15.50 lb per ft drill pipe

The new section of the string, the 334 joints of 15.50 lb per ft high-test steel pipe, is at the top of the string. Screw joints were used.

Drilling has proceeded "with no particular difficulty," according to Phillips officials, using tungsten-carbide tipped bits. Lime and sand are now being drilled. Mud viscosity is 57 seconds, weight is 11.5 lb per gal, and waterloss is 3.6.

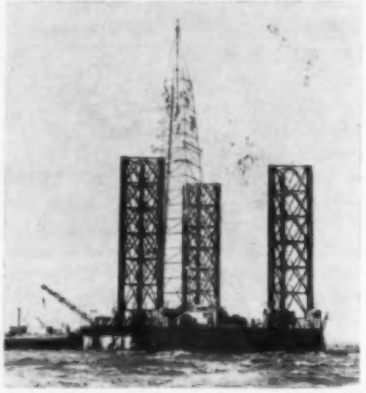
Kerr-McGee Studies Foreign Offshore

Officials of Kerr-McGee Oil Industries, Inc. are studying the possibilities of applying their company's offshore equipment and experience in foreign waters. Two company representatives have begun a trip which will include visits to England, West Germany, and Holland and might extend to the Far East. The traveling officials are Paul Wolff, Kerr-McGee's chief engineer, Oklahoma City, and J. C. Colby, special assistant to management, New Orleans.

Kerr-McGee will consider either moving existing offshore units from the Gulf of Mexico or building new ones abroad. This action is part of a growing exodus of drilling units from the Gulf area, where an estimated two-thirds of them are idle, to foreign waters where oil producing rates are higher and some of the other problems dogging U. S. operators do not exist.

Aramco Receives Drilling Platform in Persian Gulf

Arabian American Oil Company's first offshore drilling platform has arrived at Ras Tanura on the Persian Gulf following a 10,000-mile voyage from Vicksburg, Mississippi. The platform, built by R. G. LeTourneau, Inc., has undergone fitting-out operations



and received its first assignment to drill Manifa No. 2 for Aramco.

A standard 136-ft drilling derrick is mounted on the platform which stands on three 108-ft legs. The platform measures 93-ft long, 104-ft wide, and weighs about 800 tons without drilling equipment. It will work in conjunction with Aramco's drilling barge "Queen Mary."

Deep Drilling Demands Logging Refinements

West Texas' record-breaking deep drilling is calling for logging equipment of greater capacity and the ability to stand high temperatures and pressures. Schlumberger Well Surveying Corporation recently logged a deep well at 23,000 ft and then set a production packer in the well at 22,978 ft. Work was done with a winch unit capable of reaching 29,000 ft.

Down-hole tools also require special design. Standard housings for down-hole instruments are now rated for maximum pressures of 20,000 psi. The tool used in making a gamma-ray neutron survey at 23,000 ft was tested at 25,000 psi. Maximum temperature recorded in this well was 376 F. Development of the space missile program has made available high temperature components formerly unobtainable.

New Tool Pusher's Manual Available

The fourth edition of the Tool Pusher's Manual is available from the Dallas offices of the American Association of Oilwell Drilling Contractors. The book now contains 500 loose-leaf pages of technical data. Further additions and revisions of the manual are available on a subscription basis to purchasers of the book.

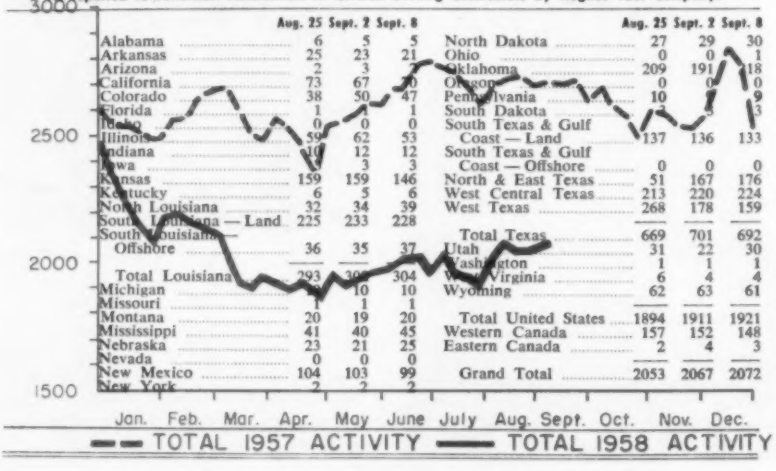
Turbodrill Sidetracks Fish in Alaska

The turbodrill was called in to assist in a sidetracking job by the drillers of a Humble Oil & Refining-Shell Oil well located in the Kanatak region of Alaska. Efforts to recover a fish at approximately 10,500 ft were unsuccessful, leading to the decision to by-pass the fish. A Dresser Industries turbodrill was chosen to do the job after preliminary efforts to sidetrack were fruitless.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

	Aug. 25	Sept. 2	Sept. 8
Alabama	6	5	5
Arkansas	25	23	21
Arizona	2	3	3
California	73	67	70
Colorado	38	50	47
Florida	1	1	1
Idaho	0	0	0
Illinois	59	62	53
Indiana	10	12	12
Iowa	3	3	3
Kansas	159	159	146
Kentucky	6	5	6
North Louisiana	32	34	39
South Louisiana — Land	225	233	228
South Louisiana — Offshore	36	35	37
Total Louisiana	293	302	304
Michigan	9	10	10
Missouri	1	1	1
Montana	20	19	20
Mississippi	41	40	45
Nebraska	23	21	25
Nevada	0	0	0
New Mexico	104	103	99
New York	2	2	2
North Dakota	27	29	30
Ohio	0	0	1
Oklahoma	209	191	218
Oregon	0	0	0
Pennsylvania	10	8	9
South Dakota	2	3	3
South Texas & Gulf Coast — Land	137	136	133
South Texas & Gulf Coast — Offshore	0	0	0
North & East Texas	51	167	176
West Central Texas	213	220	224
West Texas	268	178	159
Total Texas	669	701	692
Utah	31	22	30
Washington	1	1	1
West Virginia	6	4	4
Wyoming	62	63	61
Total United States	1894	1911	1921
Western Canada	157	152	148
Eastern Canada	2	4	3
Grand Total	2053	2067	2072



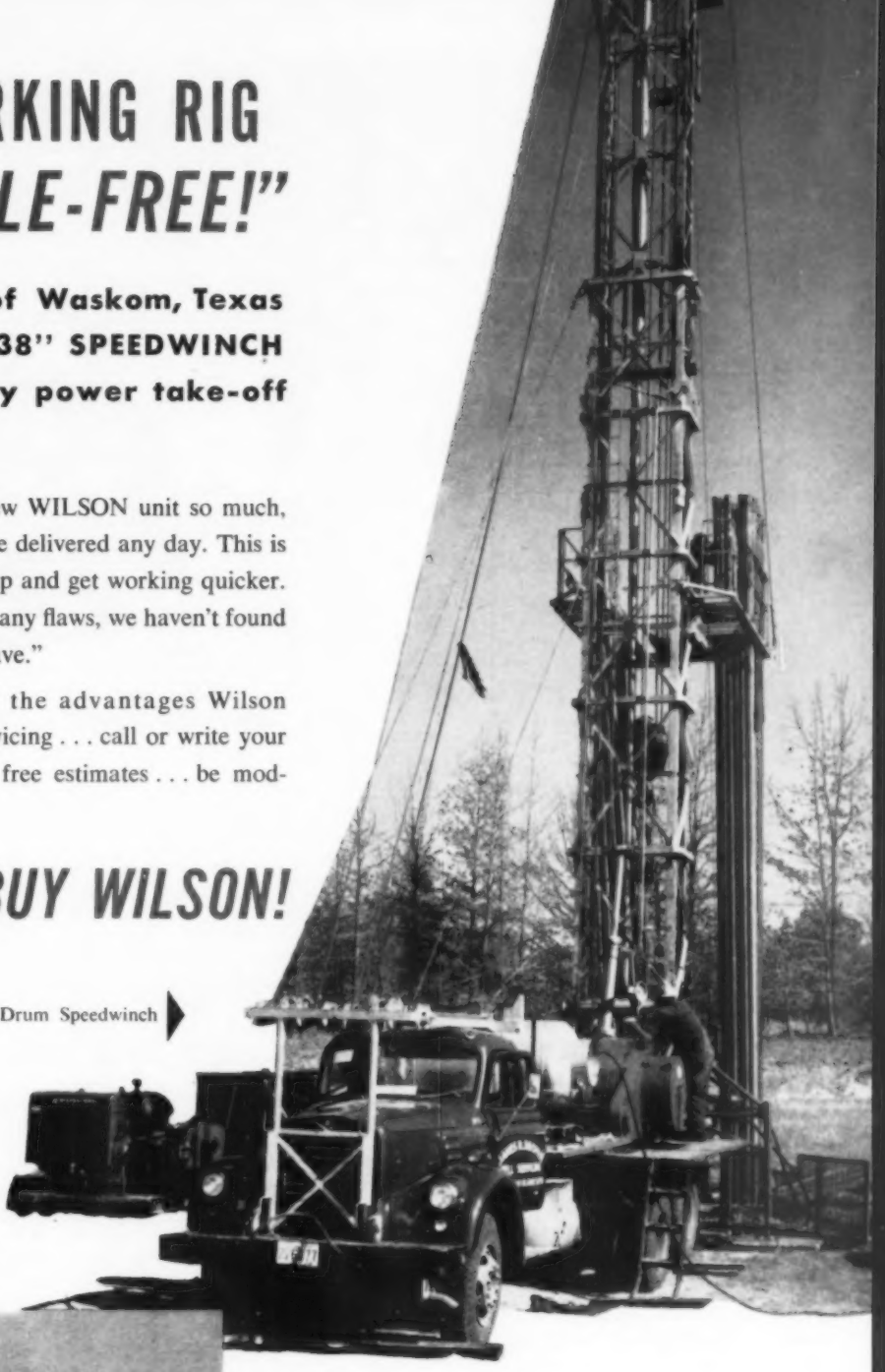
"A FAST-WORKING RIG and TROUBLE-FREE!"

says James Brown of Waskom, Texas about his WILSON "38" SPEEDWINCH featuring heavy duty power take-off and air tube clutch.

Says Mr. Brown, "I like this new WILSON unit so much, I have ordered another one to be delivered any day. This is a fast working rig. We can set up and get working quicker. It is trouble-free and if there are any flaws, we haven't found them in the toughest jobs we have."

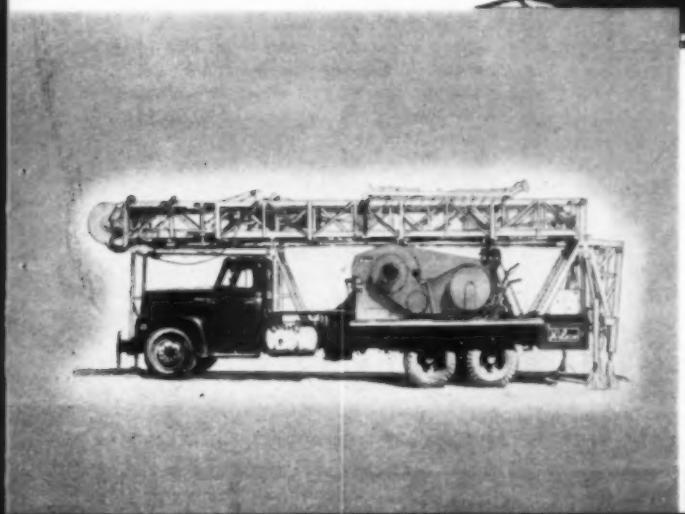
It will pay you to check all the advantages Wilson Speedwinches offer for well servicing . . . call or write your nearest Wilson sales office for free estimates . . . be modern, buy Wilson!

BE MODERN BUY WILSON!



Wilson Super "38" Single Drum Speedwinch

Wilson Super "38" Double Drum Speedwinch with Super 65' Angle Steel Fabricated Mast.



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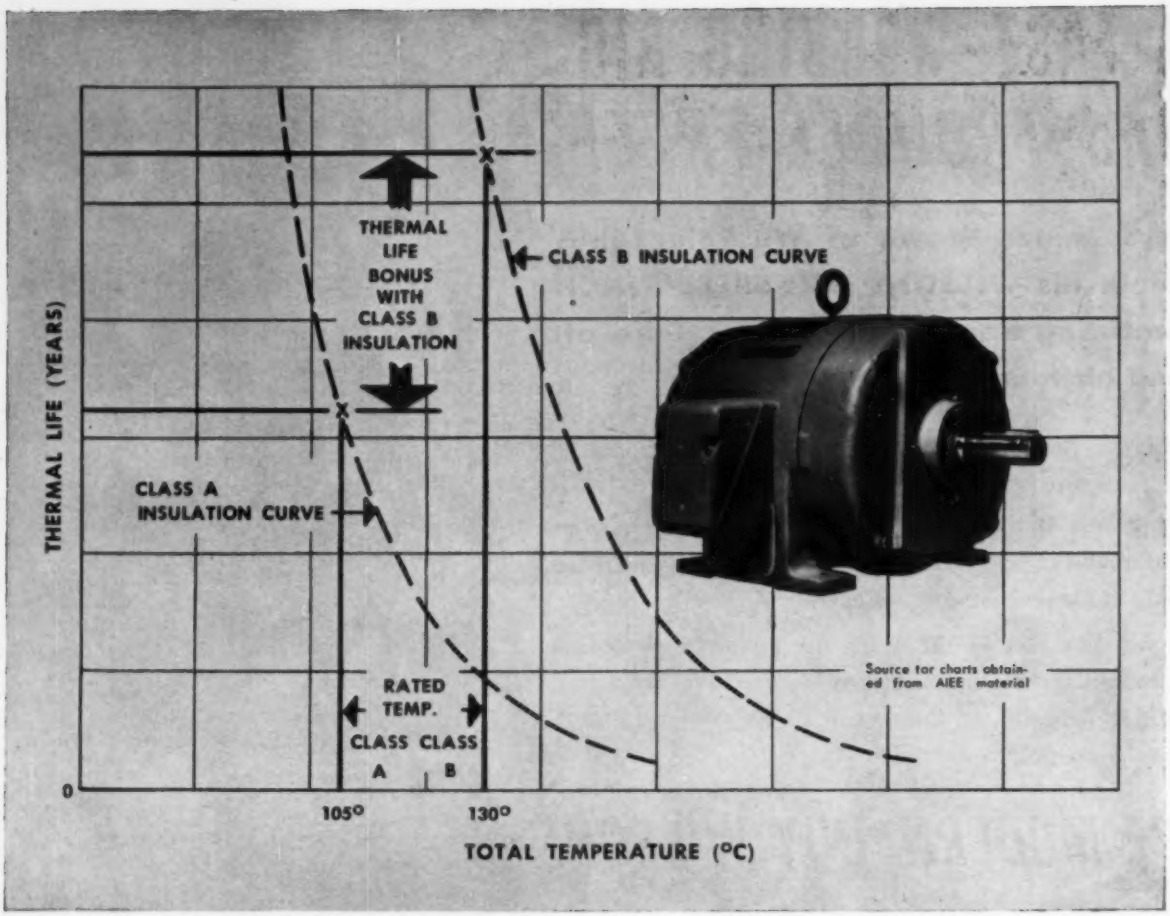


LIFE-EXPECTANCY CHART shows relative life spans of insulations. With motors operating at rated temperatures, Class B insulation gives 70% longer winding life than Class A-insulated windings.

GENERAL ELECTRIC OIL FIELD MOTORS, WITH ALKENEX* CLASS B INSULATION, OFFER . . .

70% Longer Winding Life

Recent laboratory tests—confirmed by actual field experience—have demonstrated that General Electric Oil Field Motors—with Alkenex Class B insulation—give far greater winding protection than motors having Class A insulation.

As indicated by the life-expectancy chart, windings of Class B-insulated motors will last up to 70% longer than Class A-insulated windings if both motors are operated at rated temperatures. And, since G-E oil field motors are designed to operate within actual nameplate ratings, this extra service life can be fully realized.

Even in the case of inadvertent overloading, the Alkenex Class B-insulated motors will stay on the line longer at temperatures that would burn out Class A insulations.

LONGER BEARING LIFE—To achieve longer bearing and grease life, the Tri-Clad* '55' motor provides an extra-large grease reservoir and a specially-engineered double-end ventilation system.

The grease reservoir actually holds up to five times more grease than is possible in sealed-bearing systems. And the ventilation system pulls cool air in over *both* bearing housings, so that bearing and grease temperatures are only a fraction of motor temperatures.

By utilizing these insulation, bearing, and cooling systems, G-E engineers have achieved major reductions in motor size, while actually improving performance and dependability.

PROOF IN APPLICATION—Since the General Electric Alkenex Oil Field Motor was introduced in 1956, thousands have been installed in oil fields throughout the U.S. and Canada. During this period, the performance record of these motors has been outstanding. Even the 1957 Texas floods put only a small number out of service.

This remarkable record can pay important dividends in *your* oil field pumping operation. Longer motor life, with fewer breakdowns can mean larger profits from wells. For more information on the reliable G-E Alkenex Oil Field Motor, contact your nearby General Electric distributor or Apparatus Sales Office. General Electric Co., Schenectady, New York.

*Reg. trademark, General Electric Co. 899-2

GENERAL ELECTRIC

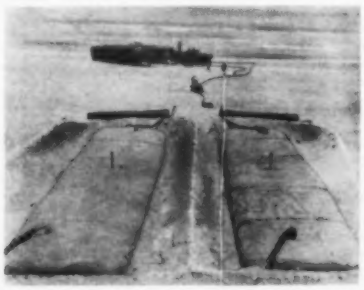
Falcon Forecasts Active Year-End

A brighter outlook for both its drilling activity and oil production during the rest of the year was forecast by Falcon Seaboard Drilling Company in its semi-annual report on its combined domestic and foreign operations. President T. N. Law said that despite the general recession during the first half of this year, Falcon has "more than maintained its position in the contract drilling business, both domestically and in its foreign operation."

During the first half of the year, Falcon drilled 16 net domestic wells, 6⅓ of which were completed as producers. Law said the well being drilled in Bolivia by Bolivian Gulf Oil Company, in which Falcon's Venezuelan subsidiary, D & D Drilling Company, has a seven percent interest, is running as expected. Falcon now operates 26 rigs in the United States and nine in Venezuela, including a new trailer-mounted rig bought earlier this year by D & D Drilling.

Portable Bulk Fuel Handling System

Drillers operating in remote areas might look to a recent development of Firestone Tire and Rubber Company for a solution to the problem of bulk fuel handling. Heart of the system, developed for the Marine Corps, is a



10,000-gal rubberized fabric tank. The tank weighs about 600 lb, less than one-tenth the weight of a steel tank of the same capacity. It can be folded into a compact package. In use, the tank is pillow-shaped, 40 ft long, 11 ft wide, and 4 ft high. Hose, connections, and pumps complete the system.

Brown Drilling Appoints Bryce to Venezuela

Charles J. Bryce has reported to Venezuelan headquarters of Brown Drilling Company and assumed charge of that operation. From offices in Maracaibo, Bryce will direct the entire Venezuelan operation for Brown, with such equipment at his disposal as a new super-powered rig shipped to the Latin nation early this year for drilling to depths up to 15,000 ft.

FIRST in their fields
CURTIN CENTRIFUGES
• Lightweight
• Rugged
• Dependable
More than thirty years' leadership is reflected in the consistent efficiency and dependable service of the Curtin Series 53 Hand Centrifuges. Some distinctive features are: (1) Rugged, lightweight aluminum castings. (2) Body, crank, spindle nut, and heads interchangeable on both 15 cc and 100 cc models. Trunnion cups replaceable. (3) Crank instantly disengages — no agitation of sediment. (4) Drive shaft and spindle are stainless steel. Spindle shaft is ball bearing mounted for easy turning. Curtin centrifuges meet all API and ASTM specifications. Both 15 cc and 100 cc models are available for immediate shipment.
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No. 3420-53
100 cc size
No. 3948
15 cc size
No. 3895
CURTIN CENTRIFUGE TUBES
• Permanently Marked Graduations
• Retested For Accuracy
• Heavy, Uniform Glass Walls
Curtin centrifuge tubes are accurately calibrated and graduations are permanently marked with white pigment fused into the glass. Graduation lines are fine and sharp to permit easy, quick reading. Every tube is thoroughly annealed for mechanical strength and individually retested for accuracy.
The tubes are of heavy-walled glass with all dimensions carefully controlled for uniformity in size and shape. Tops are finished with a machine tooled reinforced bead. Curtin centrifuge tubes meet API-ASTM specifications and are available in 15 cc and 100 cc sizes. As accuracy in testing B. S. and W. affects profits, specify Curtin Centrifuge Tubes.
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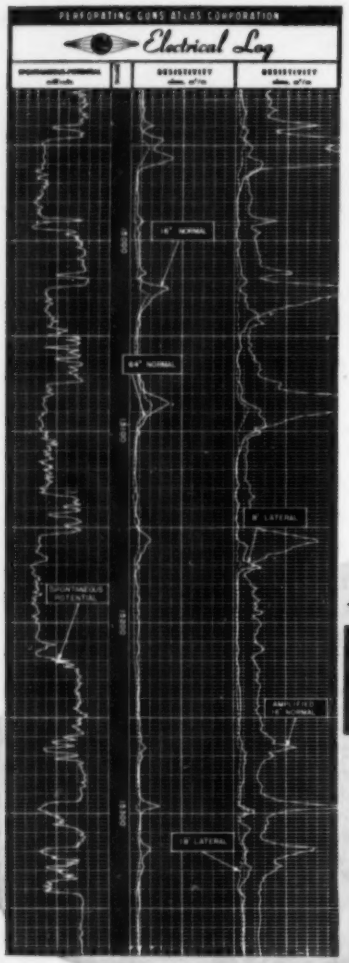
EACH HAS ITS PLACE . . . THE CHOICE IS YOURS

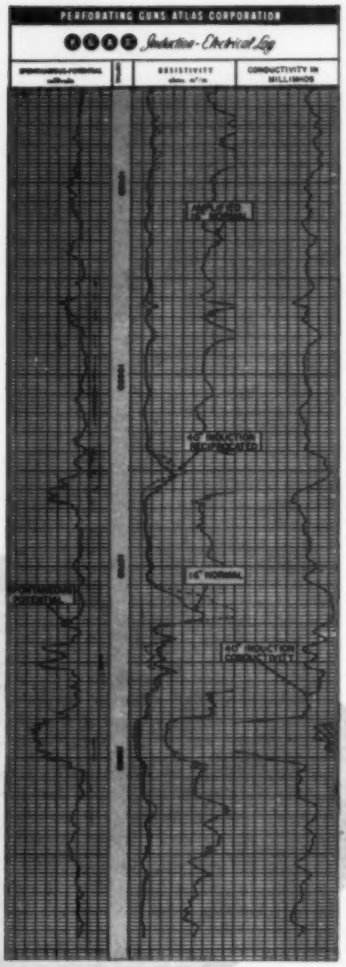
PGAC's Electrical Log OR Induction-Electrical Log



PGAC has always presented the **hard, cold facts** concerning the functions, the advantages, and the shortcomings of each type of log—so that you could intelligently choose the log you consider best for your particular job.

PGAC's Electrical Log and Induction-Electrical Log are equally fast, reliable, accurate and field-proven. However, each log has its proper applications; and PGAC's competent field engineers will gladly assist you in your choice.

PGAC-585



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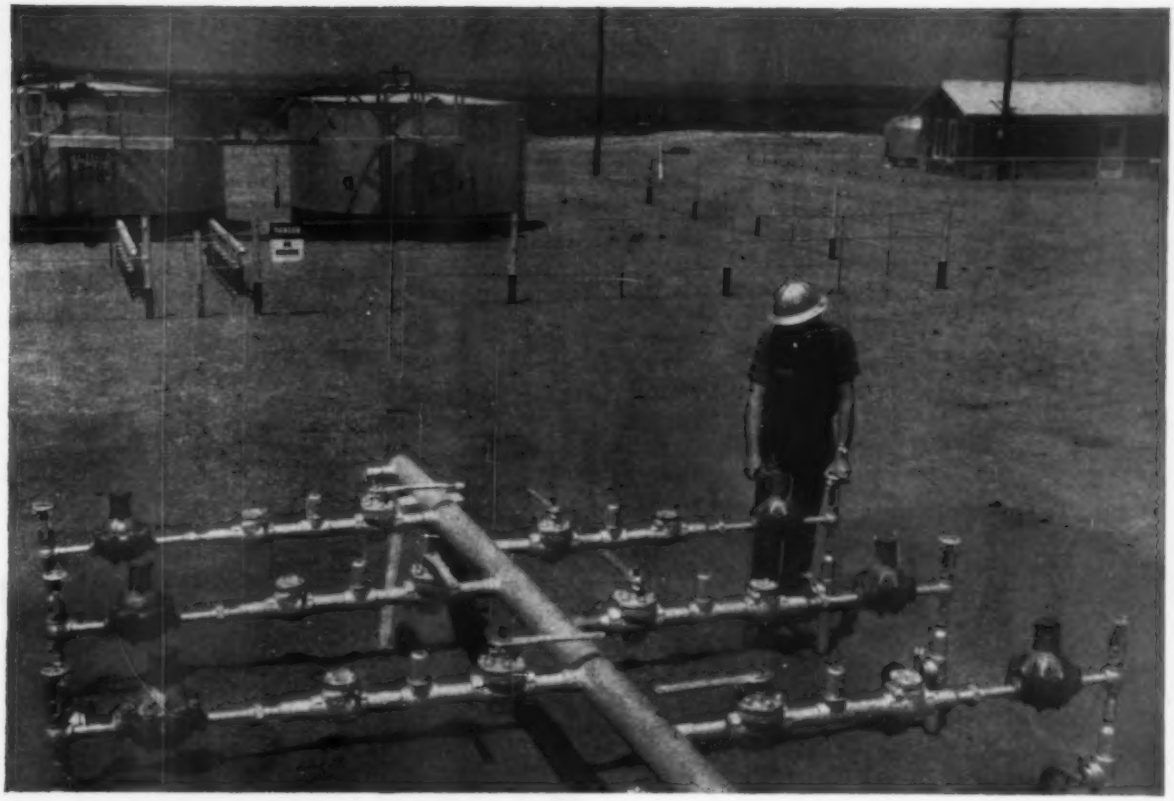

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FIVE POINTER METERS

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Cyclone action does it!

The action of the Dorr-Oliver ClayJector is demonstrated above. Cyclonic forces up to 8,000 "g's" developed when mud is whirled under pressure in a conical DorrClone® classifier, cause heavy barite solids to be thrown to the walls and down to the apex valve at the bottom, while lighter solids are discharged at the overflow at the top. Four DorrClones manifolded about a common feed, overflow and underflow housing form a complete unit.

Maximum recovery of barites for re-use and elmination of troublesome clays and drilled solids from the drilling mud not only pays off in savings of valuable weighting material, but also results in faster drilling and longer bit life.

The key to these savings is the Dorr-Oliver ClayJector classifier, developed for oil-field service through the combined efforts of Dorr-Oliver, Inc. and Salt Water Control, Inc.; it represents today's latest development for optimum control of weighted muds. A recent cost comparison analysis of one hole drilled without a ClayJector and a sidetrack hole drilled with it showed that savings with the ClayJector amounted to $32,569 in 41 days—or $795 per day!*

The ClayJector is mechanically simple, contains no moving parts, operates with minimum attention. For more information, contact our U. S. Sales Representative, Salt Water Control, Inc., 1211 Fort Worth National Bank Building, Fort Worth 2, Texas.

*Name and Statistics available on request.

ClayJector & DorrClone are Trademarks of Dorr-Oliver Incorporated

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STAMFORD • CONNECTICUT • U.S.A.

THE OASIS

gathering spot for NOMADS

Paul Bowen of S. R. Bowen Company (left) received the President's Trophy at the Golf Tournament of the Los Angeles Nomads recent Whing Ding from Earl Daniels of Hydril Company, Chapter President.

Golf prize winners at the Los Angeles Chapter of Nomads Whing Ding include Max Martin of H. C. Smith Oil Tool; C. F. Van Loozen of Macco Corporation; Frank Oefelein of Standard of California; John Davis of Totco; Lee Bortz of Halliburton; Lefty Beeson of Specialty Sales Company; Bob Pollard of Richfield; Paul Bowen of S. R. Bowen; Lee Batton of Chancelor Western Oil & Development Company; Lee Nave of Axelson Manufacturing; Art Butler of Du Pont Chemical; (in front) Nancy Cameron who distributed the prizes.

International guests at the August 1958 meeting of the Los Angeles Nomads were: Georges Caspar of LUCEAT, France; Harold Karnes of Santa Fe Drilling, Ghana; Andre Casassus of CFPA, Algeria; Wm. Pennington of Santa Fe Drilling, Iran; Virgil Davis of D & E, Brazil; Marshall C. Graham of Mosul Petroleum, Iraq; Richard C. Harris of Union Oil, Costa Rica; Ralph H. McKee of Drilexco, Brazil; C. R. Ball, Jr. of Richfield going to Peru; E. D. Strong of Santa Fe, Kuwait; J. P. Munier-Jolain of Institut Francais du Petrole, France; Sid Broom of I.P.C., Iraq; (middle row) A. M. Carmichael of Santa Fe, Iran; W. C. Lance of Santa Fe, Burma; Guy Faure of CFPA, Algeria; Dave Harris going to Alaska for his own company; W. M. Bartley of Santa Fe, Peru; Clyde C. Cantin of Bolsa Chica Oil to Turkey; (bottom row) Walt Munger of Santa Fe, Kuwait; Karl Jauman, ex-Santa Fe from Kuwait.

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the only lubricant that has

over 35 years of proven superiority... a record of less costly maintenance, "down time", stoppages and repairs than any other make.

MARVEL extra-fine lubricant is specifically designed to keep engines at peak efficiency under all the "engine-killing" conditions... in an oil field.

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TO BE SURE OF "ROUND-THE-CLOCK" PROTECTION.
Feeds MARVEL Mystery Oil in exact proportion to engine speed and load.

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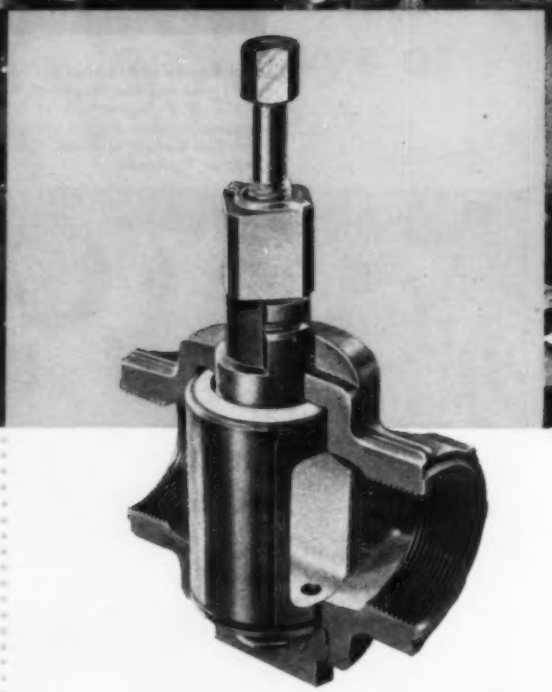

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The ACF Lubricated Plug Valve demonstrates its versatility by operating efficiently and economically in a wide range of service applications: in chemical plants, sewage and water works, paper mills, oil field production, refining, mining operations, coke plants —it's a long list.

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Both rectangular and round port valves have full pipe area openings: provide through-conduit flow with minimum turbulence, and minimum pressure drop.

. . . And W-K-M's creative engineering assures standards of design, dependability, and economy that meet your own engineering criteria.

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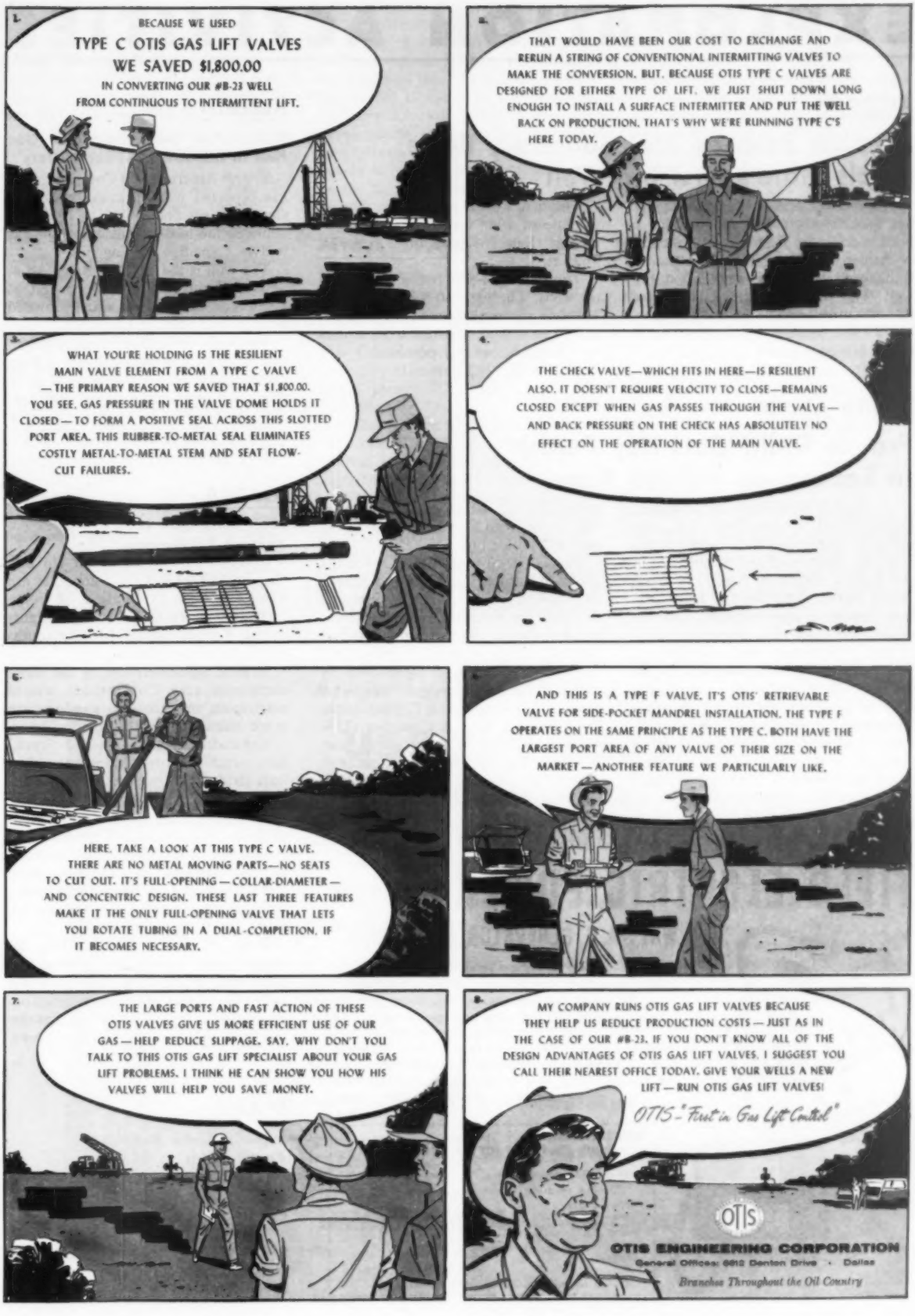
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WE SAVED $1,800.00
IN CONVERTING OUR #B-23 WELL
FROM CONTINUOUS TO INTERMITTENT LIFT.
2.
THAT WOULD HAVE BEEN OUR COST TO EXCHANGE AND RERUN A STRING OF CONVENTIONAL INTERMITTING VALVES TO MAKE THE CONVERSION. BUT, BECAUSE OTIS TYPE C VALVES ARE DESIGNED FOR EITHER TYPE OF LIFT, WE JUST SHUT DOWN LONG ENOUGH TO INSTALL A SURFACE INTERMITTER AND PUT THE WELL BACK ON PRODUCTION. THAT'S WHY WE'RE RUNNING TYPE C'S HERE TODAY.
3.
WHAT YOU'RE HOLDING IS THE RESILIENT MAIN VALVE ELEMENT FROM A TYPE C VALVE — THE PRIMARY REASON WE SAVED THAT $1,800.00. YOU SEE, GAS PRESSURE IN THE VALVE DOME HOLDS IT CLOSED — TO FORM A POSITIVE SEAL ACROSS THIS SLOTTED PORT AREA. THIS RUBBER-TO-METAL SEAL ELIMINATES COSTLY METAL-TO-METAL STEM AND SEAT FLOW-CUT FAILURES.
4.
THE CHECK VALVE—WHICH FITS IN HERE—IS RESILIENT ALSO. IT DOESN'T REQUIRE VELOCITY TO CLOSE—REMAINS CLOSED EXCEPT WHEN GAS PASSES THROUGH THE VALVE—AND BACK PRESSURE ON THE CHECK HAS ABSOLUTELY NO EFFECT ON THE OPERATION OF THE MAIN VALVE.
5.
HERE, TAKE A LOOK AT THIS TYPE C VALVE. THERE ARE NO METAL MOVING PARTS—NO SEATS TO CUT OUT. IT'S FULL-OPENING — COLLAR-DIAMETER — AND CONCENTRIC DESIGN. THESE LAST THREE FEATURES MAKE IT THE ONLY FULL-OPENING VALVE THAT LETS YOU ROTATE TUBING IN A DUAL-COMPLETION, IF IT BECOMES NECESSARY.
6.
AND THIS IS A TYPE F VALVE. IT'S OTIS' RETRIEVABLE VALVE FOR SIDE-POCKET MANDREL INSTALLATION. THE TYPE F OPERATES ON THE SAME PRINCIPLE AS THE TYPE C. BOTH HAVE THE LARGEST PORT AREA OF ANY VALVE OF THEIR SIZE ON THE MARKET — ANOTHER FEATURE WE PARTICULARLY LIKE.
7.
THE LARGE PORTS AND FAST ACTION OF THESE OTIS VALVES GIVE US MORE EFFICIENT USE OF OUR GAS — HELP REDUCE SLIPPAGE. SAY, WHY DON'T YOU TALK TO THIS OTIS GAS LIFT SPECIALIST ABOUT YOUR GAS LIFT PROBLEMS. I THINK HE CAN SHOW YOU HOW HIS VALVES WILL HELP YOU SAVE MONEY.
8.
MY COMPANY RUNS OTIS GAS LIFT VALVES BECAUSE THEY HELP US REDUCE PRODUCTION COSTS — JUST AS IN THE CASE OF OUR #B-23. IF YOU DON'T KNOW ALL OF THE DESIGN ADVANTAGES OF OTIS GAS LIFT VALVES, I SUGGEST YOU CALL THEIR NEAREST OFFICE TODAY. GIVE YOUR WELLS A NEW LIFT — RUN OTIS GAS LIFT VALVES!
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EXPLORATION ACTIVITIES

ARIZONA

Humble Extends East Boundary Butte; Finals State's First Big Well

Humble Oil and Refining Company has successfully completed its No. 1 Navajo E, in the Four Corners section of Arizona on Navajo Tribal Land. It is believed to be the state's first big well. The producer extends the East Boundary Butte field, opened by Humble in 1955, to the south. It is located in C SW NE of 10, 41n, 28e.

The new well is reported to flow at the rate of 1044 bbl daily and is producing from Hermosa lime at 4600-4675 ft.

The field now has two gas and two oil wells. The first oil well drilled by Humble was located in section 4. It was drilled to a total depth of 6382 ft and had a 48 bbl per day potential.

NORTH AFRICA

Franco Delhi Gets Key Permit In Sahara on 445,000 Acres

A French subsidiary of Canadian Delhi Oil Ltd., Franco Delhi, S.A., and associates were awarded a permit to explore for petroleum and natural gas in the Sahara region of Algeria, French North Africa. The Daiet el Habs permit—covering approximately 445,000 acres—lies midway between Hassi R'Mel, the Sahara's major natural gas field, and Hassi Messouad, the largest oil field. Hassi R'Mel is a condensate bearing gas field with proved reserves reportedly in excess of 11 trillion cu ft, and is located approximately 75 miles west of the Franco Delhi permit area. Hassi Messouad is a 43 deg oil field approximately 80 miles southwest of the permit, with proven reserves in excess of 2 billion bbl.

Franco Delhi is the operator for the group of French, Canadian and American entities, with participating interests divided approximately as follows: Franco Delhi, 30 percent; Petropar (owned by the French Government), 35 percent; Francarep (sponsored by the French banking firm Worms & Rothschild), 16 percent; E. Constantin, Jr., 6 percent; Allen & Company (U.S. investment banking firm), 7 percent; Vaughn Brothers' Trusts, 3 percent; Home Oil Company, Ltd., 3 percent.

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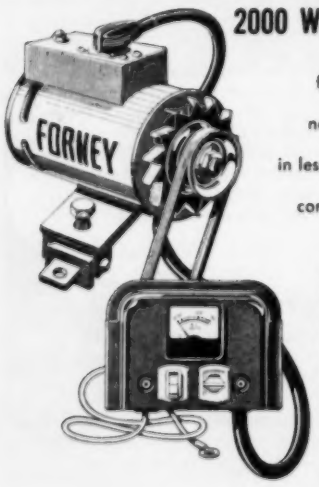

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ALBERTA

B-A Makes 'Most Significant Gas Find in Canadian Drilling History'

British-American Oil Company, Ltd. has reported what it calls "the most significant gas find to date in 1958 and could be the most significant single gas find in Canadian drilling history."

The well is the Berland River A8-4, located about 160 miles northwest of Edmonton on a block equally owned by B-A and Shell of Canada.

The well tested at a rate of 44,800,000 cu ft of gas daily through a 1-in. choke and did 12,900,000 cu ft daily through a ⅜-in. choke. Well had earlier been reported to have an open flow potential of 1.5 billion cu ft of gas daily.

ALASKA

Threesome Join in Yakutat Exploration

Continental Oil, Colorado Oil and Gas, and Frankfort Oil companies are joining in the exploration of some 1,100,000 acres of oil and gas rights in the Yakutat area along the southeastern coast of Alaska.

A joint announcement by the three companies said Continental would participate in extensive exploration work extending into 1960.

Colorado Oil and Gas and Frankfort, which hold the oil and gas rights, have drilled two exploratory test wells with encouraging oil and gas indications. A third test now in progress is projected to a depth of 11,000 ft.

In addition to the drilling, Colorado Oil and Gas and Frankfort have since 1956 conducted in the area extensive seismograph, gravity meter and surface geological surveys.

Projected exploration operations include further geophysical surveys and additional exploratory drilling. Colorado Oil and Gas has an established operating base in the village of Yakutat and will continue supervision of operations of the properties.

UTAH

Superior Links McElmo, Aneth Fields in Four Corners

Superior Oil Company has linked the McElmo and Aneth field in San Juan County with a 608 bbl per day oil well.

The No. 13-31 Navajo C, in C NW SW of 31, 40s, 25e, was completed on choke from two perforated zones between 5399 and 5478 ft.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

OKLAHOMA

Kirby Has Multi-Zone Discovery in McClain County

Kirby Petroleum Company has completed its multi-zone discovery well in the Oil Creek zone. The No. 1 Weeden, south of the East Washington field in McClain County, was drilled to 10,190 ft.

On a 12-hr completion test of the Oil Creek, the Weeden flowed 186 bbl of oil through ½-in. choke from 10,048-50 ft.

Wildcat also had commercial shows of oil in the Bromide, Tulip Creek and McLish sands.

PERSIAN GULF

ADMA Tests Show Promise

Abu Dhabi Marine Areas Ltd. (British Petroleum and Compagnie Francaise des Petroles) has been encouraged by recent developments of its operations, based on Das Island, in the Persian Gulf waters off Abu Dhabi.

Umm Shaif No. 1 Well has now been drilled to a depth of 8755 ft and tests have been completed of the Jurassic Arab zone limestones, from which only gas was produced. Testing of the lower cretaceous Shuaiba limestone is still in progress, but the well has already flowed oil for a limited period at a rate of approximately 2400 bbl per day. This oil is of 40 deg API with a sulfur content of about 1.4 percent. Although the results of this first well do not give final proof that an oil field has been found which will justify commercial development, the indications are sufficiently encouraging for the company to decide to drill further appraisal wells on the same structure.

PENNSYLVANIA

New Discovery Prospect In Appalachian Basin

An apparent new discovery is being completed in the Appalachian Basin. The Crawford County prospect was drilled by Hamilton Oil & Gas Corporation, Denver, Colorado, on a 1336-acre block.

Drilled to the Medina sand, operator reported 40 ft of oil sand in the interval 3402-42 ft, and good oil shows from 3498-3520 ft. No tests were run until production string had been set.

Benedum-Trees Oil Company made the first discovery in the area last September, the first production in Crawford County in over 50 years. This new production earned the title of the "discovery of the year" for the region.

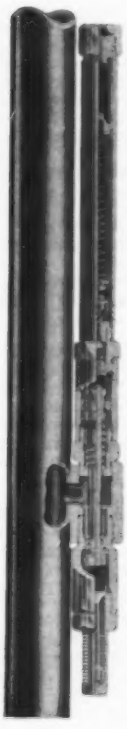
COLORADO

San Juan Extension Indicated by Gas Discovery

Initial completion tests of the recent wildcat dual zone gas discovery in La Plata County have been run by Consolidated Oil & Gas, Inc. of Denver, Colorado, operator of the well.

The significant new gas discovery, No. 1-6 Superior Ute, was drilled by Consolidated Oil & Gas, Inc., as operator in association with Occidental Petroleum Corporation and Black Bear Consolidated Mining Corporation on an 8000-acre block. Using San Juan Basin standard testing procedures for initial potentials, gas flowed through a ¾-in. choke at the rate of 1,585,000 cu ft per day from 76 ft of perforations in the Fruitland formation and 1,750,000 cu ft per day from 219 of perforations in the Mesaverde formation. This initial potential test also indicated open flow capacities from the Fruitland of more than 3,000,000 cu ft per day, and from the Mesaverde of more than 4,000,000 cu ft per day.

Name has not yet been designated for the new field discovered by successful completion of this wildcat well, 7 miles south of Bayfield. A large scale development program of the block is planned for 1959.



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Footnote: Methods covered by U. S. Patent No. 2,642,811

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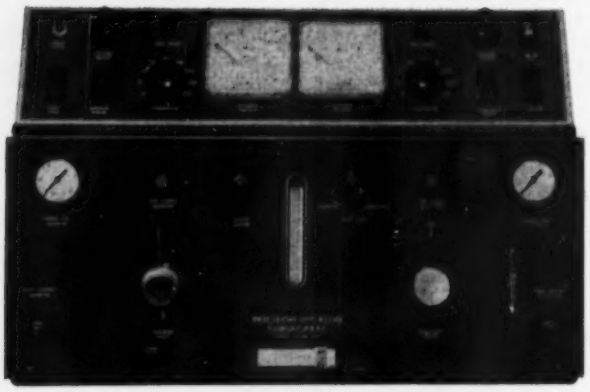

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RUNNING TOUR with

▸ **T. L. Russell** has received a PhD degree in mechanical engineering at Caltech, and joins drilling research group of California Research Corporation as a research engineer. **J. B. Money** has received a BS degree in petroleum engineering from the University of California and joins the reservoir mechanics group as a research engineer. **E. L. Dougherty** has also joined the reservoir mechanics group as a research engineer. He was previously with the Dow Chemical Company.

▸ **S. T. Duree** has retired as a senior production superintendent for Cities Service Oil Company's South Texas production operations. **D. S. Bodie** will supervise the consolidated South Texas district from his offices in Columbus, Texas.

▸ **J. P. Malott,** Houston, has been promoted to assistant general manager of Continental Oil Company's Rocky Mountain region, with headquarters at Denver, Colorado. Formerly manager of Conoco's headquarters production department at Houston, he will succeed **L. L. Aitken,** who recently resigned to become executive vice president of Utah Southern Oil Company. **Wayne E. Glenn,** Denver, assistant Rocky Mountain region production manager for Conoco since 1952, has been promoted to manager of Conoco's headquarters production department at Houston, succeeding Malott.

Glenn C. Sawvel has been promoted to superintendent of Continental Oil Company's Oklahoma City production district. Formerly assistant district production superintendent in Oklahoma City, he succeeds **D. W. Matthews,** who has transferred to Wichita, Kansas, as assistant division superintendent of Conoco's Kansas production division.

M. H. Dubrow has been promoted to the newly created position of assistant manager of the company's headquarters production department. Dubrow was chief engineer in Conoco's production department. **R. F. Darrow** has been promoted to assistant manager of production for the company's Rocky Mountain region. He was formerly superintendent of production for Conoco's Kansas division.

▸ **W. S. Frisbie** has been appointed special representative of Falcon Seaboard Drilling Company. He will also work with Falcon's wholly-owned subsidiary, D & D Drilling and Construction Company in Anaco, Venezuela.

▸ **George Standard,** drilling superintendent for Harkins & Company of Alice, is retiring. Replacing Standard in the Harkins organization will be **Ray Butler,** formerly production superintendent. **Wilbur T. Steen,** tool pusher with Harkins and previous firms for 12 years, has been named assistant to Butler.

▸ **Harry Mummert,** veteran independent oil operator, has joined Stekoll Petroleum Company to direct a new program of production purchasing.

▸ **Bert E. Gamble,** manager of the Southern region for Lion Oil Company Division of Monsanto Chemical Company, has retired from the company. Gamble, who joined Lion in 1937, has been in his present position since 1952. He will be succeeded by **Wilbert C. Dennis** who was chief geologist for the company in its production and exploration headquarters.

MEN in the INDUSTRY

J. W. Higgins, district geologist for Standard Oil Company of California's exploration department has been appointed senior research geologist for the California Research Corporation. **R. A. Armstrong,** petroleum engineer with The California Company at their Denver office, has transferred to the oil field research center of California Research where he he will undertake assignments in production research. **H. C. Mitchell** has completed work toward the MS in petroleum engineering at Stanford and has accepted appointment as research engineer in reservoir mechanics. **R. D. Tooley** has completed his work for the PhD at MIT and has accepted an appointment as research physicist.

Dr. F. W. Oudt, area exploration manager, has been promoted to executive assistant to the vice president, Shell Oil Company's New Orleans exploration and production area. He succeeds **W. M. Johnson,** who will continue to assist the vice president with industry affairs and special assignments. **G. A. Burton,** area geologist, has been appointed area exploration manager succeeding Oudt.

Orland M. Reiff, chemist, and **Paul B. Weisz,** physicist, Socony Mobile Oil Company, Inc., have been promoted to the new post of senior research associate at the company's research and development laboratory.

T. A. Huber, assistant chief petroleum engineer for Humble Oil & Refining Company, was presented a plaque recently in recognition of his outstanding achievements in the field of reservoir engineering. The certificate stated that "with prophetic vision, the recipient pioneered and actively promoted the application of reservoir engineering from its modest beginning to its present eminence and thereby contributed immeasurably to the economic growth of Humble. He . . . has set a pattern followed by industry for the application of reservoir engineering in production operations."

Richard W. Coburn has been appointed vice-president in charge of field operations for W. E. Stiles Engineering, Inc. Coburn, formerly assistant to vice president for production, and district superintendent, for Champlin Oil and Refining Company, will direct all of the drilling and producing operations on oil and gas properties managed by Stiles Engineering.

Lloyd Armstrong has been appointed a vice president of Tidewater Oil. Prior to that he served as assistant general manager of the southern division in Houston. **Thomas G. Kelliher** will succeed Armstrong. Kelliher was formerly manager of exploration for the company's southern division.

John H. East Jr., regional director of the Bureau of Mines' eight-state region III, has been voted the Department of the Interior's Distinguished Service Award and Gold Medal.

Karl R. Kuhn, office manager for Utah Southern Oil Company, has been elected by the board of directors to the position of treasurer and assistant secretary, and **Harry E. McDonald** has been named production superintendent. McDonald was previously with the oil department of the Mercantile National Bank of Dallas.

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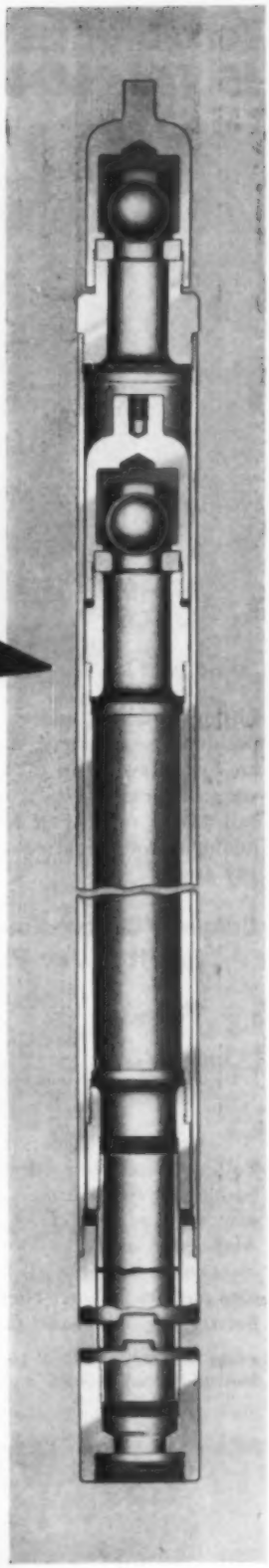

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Running Tour

G. L. Romine

▸ **Kenneth R. Joynt** has assumed the duties of superintendent of Magnolia Petroleum Company's Gulf Coast Producing Division. Formerly the assistant superintendent, Joynt will replace **J. B. Goodrich** who is retiring. **John S. Russell** will replace Joynt in his former position.

▸ **Gordon L. Romine** has joined the staff of Keplinger and Wanemacher as a petroleum engineer. Romine was formerly with the Lion Oil Company, Division of Monsanto Chemical Company.

▸ **Jack Cashell** has been elected president of the Preston Oil Company. Cashell had been vice president since 1950 and general manager since 1954.

▸ **C. J. Christensen** has been named division production superintendent for Pan American Petroleum Corporation's Canadian division, with headquarters in Calgary, Alberta. He succeeds **T. C. Borland,** who will become vice president-production and a director of Pan American International Oil Company. Christensen has been assistant division production superintendent for Pan Am's Rocky Mountain division since 1953.

▸ **Denis B. Kemball-Cook,** a director and vice president of Shell Caribbean Petroleum Company, has been named executive vice president in charge of exploration and production for Shell Oil Company. Kemball-Cook will succeed **Alan J. Galloway,** who is retiring after 32 years with the firm.

▸ **Wilfred B. Tapper** has been named vice president of Chaco Petroleum, S. A., Bolivian subsidiary of Tennessee Gas Transmission Company. He was formerly general manager of operations.

▸ **E. R. Downs,** formerly assistant division superintendent of the Ohio Oil Company's Shreveport production division, has been appointed division superintendent succeeding **R. W. Fawcett,** who retired.

W. O. Miller

▸ **W. Doyle Miller** has been elected a director of Seminole Oil & Gas Corporation. Miller is an independent petroleum and management consultant in Dallas, Texas and Wichita, Kansas. He is also president of Miller Petroleum Company.

▸ **Martin H. Mitchell** was appointed general manager of Tidewater Oil Company's operations in Pakistan. From his headquarters in Karachi, Mitchell will direct oil exploration on concessions totaling 10,000 square miles in West Pakistan. Mitchell previously served two years as general manager of Tidewater's exploration and production operations in Turkey.

▸ **F. Walker Johnson** has been elected a vice president and director of The Jersey Production Research Company, Tulsa, Oklahoma. He was formerly assistant manager of exploration with the Creole Petroleum Corporation.

▸ **J. B. Storey** and **Fred R. Schroeder,** have been elected vice presidents of Union Producing Company. Both were previously directors for the company. **W. J. Quigles** has retired as senior vice president after 28 years with Union Producing.

▸ **E. A. Schiffers,** Pan American Petroleum Corporation's Andrews area operations engineer at Andrews, Texas, has been transferred to Midland, Texas, and promoted to operations engineer in the district office.

W. J. Price

J. C. (Jimmy) Johnston, formerly manager of Continental Oil Company's production operations in the Rocky Mountain area for the past 20 years has retired. **John W. Tynan,** previously regional engineer for Conoco in Denver will succeed Johnston.

▸ **W. J. Price** has been appointed as manager of Loffland Brothers Company, European operations. Price has had long experience in foreign drilling activities in South America and was formerly with Loffland Brothers as foreign contract representative.

Running Tour

▸ The transfer of Pan American Petroleum Corporation's overseas operations in the western hemisphere to the jurisdiction of its subsidiary, Pan American International Oil Company, has been announced. **G. J. Smith, D. W. Farnham** and **K. C. Thompson** have moved from Tulsa to the New York offices of Pan American International. All three have been associated with exploration, drilling and production activities of Pan American Petroleum subsidiaries operating in the Caribbean area. Smith's new title is exploration superintendent for the Western Hemisphere; Thompson is chief geophysicist, and Farnham is operating superintendent in Pan Am International's production department. **J. C. McCarthy,** formerly Rocky Mountain division engineer, has been promoted to assistant division production superintendent; **J. W. Phenicie,** formerly assistant division engineer at Pan America's Texas-Louisiana Gulf Coast division, has been promoted to division engineer in the Rocky Mountain division; and **C. J. Christensen,** formerly assistant division production superintendent in the Rocky Mountain division, has been promoted to division production superintendent for the Canadian division. **L. E. Brock** has been appointed assistant to the production superintendent at Pan Am's North Texas-New Mexico division. He was previously in charge of the unitization section.

▸ **E. R. Downs,** formerly assistant division superintendent of the Ohio Oil Company's Shreveport production division, was recently appointed division superintendent succeeding **R. W. Fawcett,** who retired.

▸ **George W. Field** has been appointed manager of exploration for Cities Service Oil Company's southern division. **Perry E. Barnhart** is to succeed Field as southern division geologist at Houston. Barnhart's job as district geologist at Lafayette will be filled by **R. O. Donley Jr.** of Lafayette. **H. Ben Cox** is retiring from Cities Service after almost 35 years of service in the company's land-geological division.

W. L. Ambrose has been appointed superintendent of safety and supervisory training for Cities Service. He succeeds **E. R. Estus** who will continue to serve on a part-time basis in a consulting capacity.

▸ **D. C. Dunaway** has been elected president of American Independent Oil Company. He was previously president of the Standard Oil Company of Argentina.

▸ **Andrew G. Alpha** has been transferred to the general offices of Signal Oil and Gas Company in Los Angeles as exploration coordinator. Alpha had been with Signal's Denver office since 1953, when he joined the company as geologist for the Rocky Mountain area and Canada.

▸ **I. J. Pierce** has joined Reading & Bates Offshore Drilling Company as manager of the firm's newly created land and exploration department. Pierce was formerly division manager of the land and geological department of Phillips Petroleum Company in Oklahoma City.

▸ **Karl R. Kuhn,** office manager, has been elected to the position of treasurer and assistant secretary of Utah Southern Oil Company. **Harry E. McDonald** has been named production superintendent.

▸ **C. M. MacInnes** has been appointed secretary and **H. W. Bliss** as treasurer of Baily Selburn Oil & Gas Ltd. MacInnes has been associated with Baysel since the company was formed in 1952. Bliss, who will serve as comptroller of the company as well as treasurer, is a chartered accountant.

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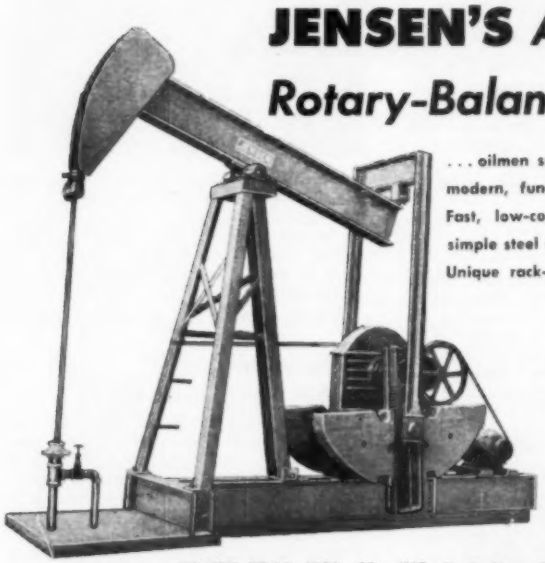

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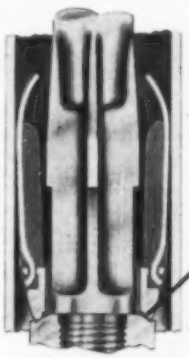

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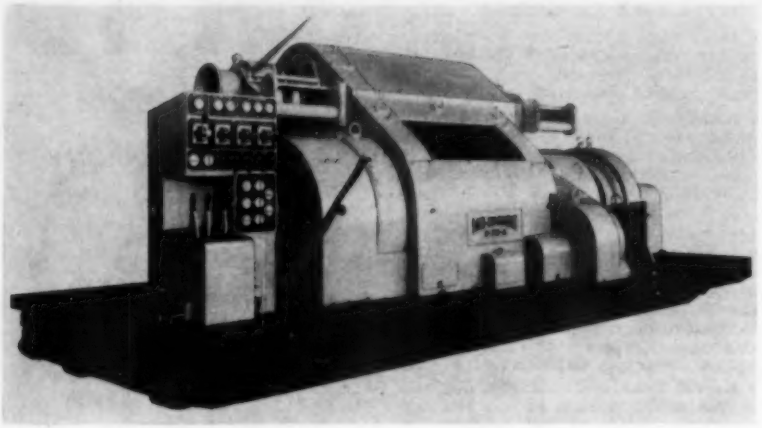

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Faster and more efficient drilling is a feature of a new drawworks, the U-712-A, being offered by Mid-Continent Supply Company. Operating controls have been incorporated into a single console, increasing the efficiency of the driller. This centrally-located panel is equipped with speed selection levers and air-actuated clutch controls. The U-712-A, manufactured by Unit Rig & Equipment Company, is designed for medium depth drilling in the 8000-12,000 ft range.

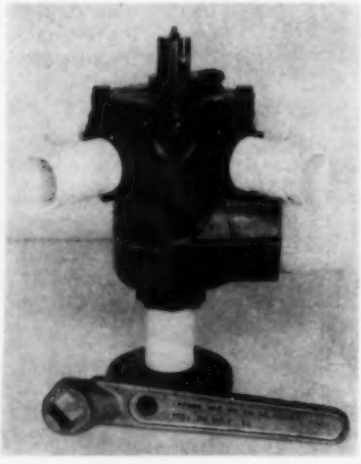
Rated at 700 to 1200 net input horsepower, this single package unit contains hoisting drum, transmission, rotary drive, and auxiliary brake. The drawworks, weighing approximately 43,750 lb, is less than 10 ft wide and can be easily transported on the highway.

Two-shaft transmission with 3 forward rations and a gear reverse combine with the hi-drum and lo-drum drives to give 6 forward and 2 reverse speeds at the hoisting drum. Three forward and one reverse speed are available to the rotary countershaft, catshaft, and sandreel. All transmission shafts, mounted in identical support bearings, can be removed independently. *Mid-Continent Supply Company.*

Circle number (1) on reply card.

Four-Way Manifold Valve

A new 4-way manifold valve for waterflood projects or primary production is designed to enable the producer to hook up 4 wells into one valve, with one well on test and the other 3 on production. The valve has one 4-in. comingling outlet, four 2-in. inlet ports, and one 2-in. test port. Any of the 4 inlet ports can be placed on test by rotating the handle to that position. The overall size is 12½-in. high and 8¾-in. wide, and the weight is approximately 60 lb. Valve is available with either Teflon or Marlex packing and standard design provides for a working pressure of 125 psi. *Enardo Manufacturing Company.*

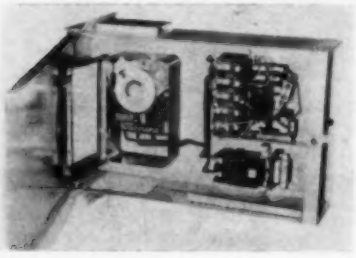


Circle number (2) on reply card.

All-Weather Oil Well Panel

A new all-weather oil well panel, which provides precision pumping through automatic control, has been announced by Federal Pacific Electric Company. Designed for use with single phase pumping units up to 5 hp at 220 v, or 2 hp at 110 v, 60 cycle operation, the panel is particularly adapted for the control of shallow oil well pumps.

Main elements in the panel are its time clock, motor starter and short circuit protection device. The time clock, with adjustable settings over a 24-hr period, comes housed in a separate compartment for maximum protection against the elements and is readily accessible. *Federal Pacific Electric Company.*



Circle number (3) on reply card.

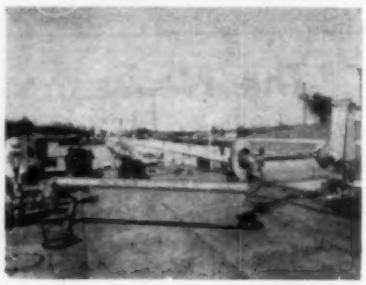
Dual String Pin Packer

Texas Iron Works has announced a new Type DS series of dual string pin packers designed for use as the upper packer in a dual completion well using 2 production strings. Compression type elements are used for packing off the upper production zone, and anchoring slips prevent high compression loads on the tubing below the packer. It is completely retrievable by pulling the lower tubing. Upper tubing may be pulled at any time without disturbing the packer. *Texas Iron Works.*

Circle number (4) on reply card.

Mechanical Barge Loading Arms

Two all-metal models of a barge and tanker loading device, designed for transfer of petroleum products, are available from Chiksan Company. The device is available in both 6 and 8-in diam. Materials handled include black and bright petroleum products and mild caustics. Either unit safely handles products in —60 F to 225 F temperature range at pressures to 300 psi. *Chiksan Company.*



Circle number (5) on reply card.

Reduced Wear Sucker Rod Coupling

Axelson Manufacturing Company has developed a corrosion and wear resistant API sucker rod coupling with a friction coefficient of 0.10, compared to a coefficient of 0.40 for hard steel. Tests show a wear reduction of 2 to 1 in wells with low water production, and more substantial reduction in tubing and coupling wear may be expected in high water cut, crooked hole, and abrasive wells. The hardfacing surface has a porosity of approximately 2 percent, and contains microconstituents attaining a hardness of 9 on the Mohs scale. *Axelson Manufacturing Company.*

Circle number (6) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Free Flow Combination Tools

Oil Well Cementing Company, Inc., has introduced their free flow combination tools for service in squeeze cementing, fracturing, acidizing, casing testing, casing perforating, and collar locating. The tools are made for work in wells with size ranges from 4¾ to 8⅝ in.

Casing perforator is the expendable type and can be inserted in drill pipe or tubing at surface and pumped down the well with rig pump or cementing unit. The perforator is actuated entirely by hydraulics and cannot be accidently fired on the surface. *Oil Well Cementing Company, Inc.*

Circle number (7) on reply card.

Powered Lifting Hoist

A new powered lifting hoist, called an Auto Crane, has been developed to make feasible one-man handling of loads up to 1000 lb. The hoist can be installed in the trunk of a car or in the bed or on the side of a pickup truck. The unit is powered

by the vehicle battery (6, 12 or 24 v) and is operated by a cable-mounted movable hand switch.

The moving mechanism is fully enclosed, except for usable cable used for hoisting. Boom telescopes and swings out of the way for road travel. The unit is also dolly-mounted for use in shops. *Auto Crane Company.*

Circle number (8) on reply card.

SECONDARY RECOVERY
Since 1922

PETROLEUM ENGINEERS
CABLE & STEPHENS
WICHITA FALLS, TEXAS

RESERVOIR ENGINEERING
Water Flooding Gas Repressuring
EVALUATION CORE ANALYSIS
SURVEYS ECONOMICS
Cost Estimates, Design, Installation
FIELD SUPERVISION
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CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy cleanout with fewer round trips and less downtime, use world famous Miller Sand Pumps.

Write for descriptive price list.

SAND PUMP SIZES IN STOCK

O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 in. Lengths, 20, 25, 30 ft.

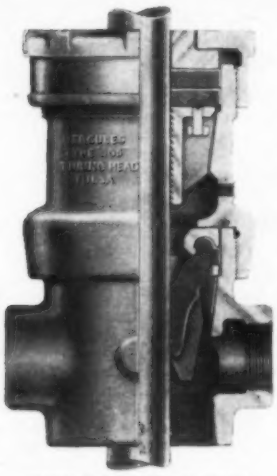
Composite Catalog Page 3419

MILLER SAND PUMPS

Miller Sand Pump Co.
General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK 20, N. Y.

there's a Hercules tubing head TO FIT YOUR REQUIREMENTS...

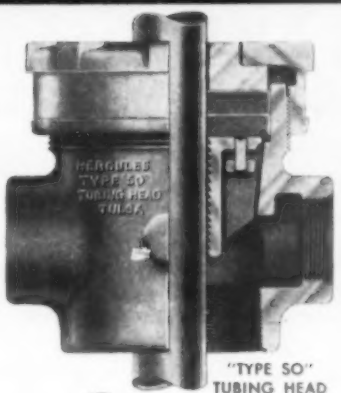


"TYPE SOS" TUBING HEAD

HERCULES "Type SO" Tubing Head is particularly suited for pumping due to compactness (only 12½" high). Stripper rubber can be used in body for running or wiping tubing. Also ideal for intermittently flowing wells.

HERCULES "Type SO" and "SOS" Tubing Heads are the favorite of successful operators because of their simplicity, ruggedness and ease of operation. Available in 4½" OD to 7" OD Casing Sizes to suspend 2", 2½" or 3" tubing. Constructed from pressure cast steel and tested to 4,000 PSI. Slips are hinged for ease of installation and positive alignment.

HERCULES "Type SOS" Stripper Tubing Head is unsurpassed for use in well servicing operations as well as on flowing wells. It consists of a HERCULES "Type SO" Tubing Head with a bowl and Neoprene Tubing Stripper.

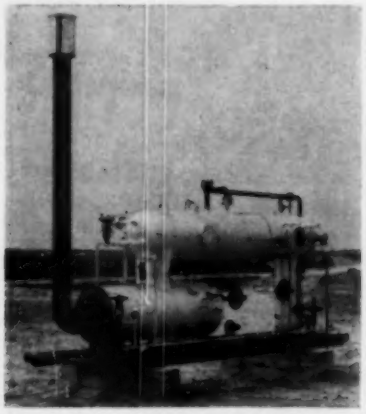


"TYPE SO" TUBING HEAD

HERCULES TOOL Company
"MANUFACTURERS OF OIL FIELD EQUIPMENT" SINCE 1924
GENERAL OFFICES AND PLANT TULSA, OKLAHOMA
Export Representative: Oil Field Equipment Co., Inc., 30 Church Street, New York 7, N. Y.

Available through all supply stores:

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Low-Temperature Gas Separator

National Tank Company has designed a new and improved method for handling high to moderate pressure distillate wells, particularly when flow-rate requirements vary over a wide range of operations, rates from 1/10 of a million per day up to rated recommended capacities, with ability to care for wide differences of throughput during the same 24-hr period. *National Tank Company.*

Circle number (9) on reply card.

Pulsation Dampener

Ball Manufacturing Company, Inc., has introduced a new Type BL pulsation dampener, designed to be installed directly in the discharge line of the pump. Due to the through-flow, inline construction of the dampener, all pumped fluid is more effectively controlled.

A specially designed, synthetic rubber bladder is in a non-stressed condition when it is pre-charged with nitrogen. It is able to flex in an unilateral movement in absorbing the pressure surges with the minimum amount of stretching and wrinkling. *Ball Manufacturing Company, Inc.*

Circle number (10) on reply card.

Gas-Powered Instrument Clock

The Gasclok, a self-contained air or gas powered instrument drive and timing unit, has been introduced by American Meter Company. It can be used as either original or replacement equipment and is said to deliver a constant power output of more than 20 times the torque supplied by spring-wound clock mechanisms. The unit can be used with all types of instruments requiring chart records from 1-hr to 30-day periods. It has a gas or air consumption of 5 cfh at its normal operating pressure of 5 psi. *American Meter Company.*

Circle number (11) on reply card.

Nuclear Magnetometer Prospecting Tool

The Varian nuclear precession magnetometer, an instrument used in the Vanguard earth satellite and Aerobee rocket programs, has been introduced by Spartan Air Services Limited, Ottawa, as an airborne prospecting tool. The instrument measures the oscillation of hydrogen atoms in a sensing element under the influence of the earth's magnetic field. The frequency of the oscillation is proportional to the earth's magnetic field at any point. This frequency is then recorded on punched tape for convenient computer processing. Computer results, when mapped, give evidence of the presence of basement topography and thickness of overlying sedimentary section. Measurements are independent of orientation of the instrument with respect to the earth's magnetic field. *Spartan Air Services Limited.*

Circle number (12) on reply card.

Multiple-Seal Gate Valve

Vernon Tool Company, Ltd., has announced the addition of a new multiple-seal gate valve to their line of valves, designed for aromatics, hydrocarbons, and LPG. The valve offers 2 precision metal-to-metal seats and 2 secondary "O" ring seals. It operates the same way as any conventional rising-stem gate valve, but because of its precision metal seats and "O" ring seals, it is closed hand-tight only and no snipe is used. Valves are made of cast steel with stainless steel trim and all face-to-face dimensions conform to ASA specifications. *Vernon Tool Company, Ltd.*

Circle number (13) on reply card.

ROCKFORD

OIL FIELD TYPE

LONG LIFE
Heavy-Duty

POWER TAKE-OFF

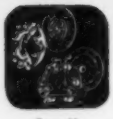
Handles 5000 Pound Belt Loads

Eliminates the Pilot Bearing
Release and Main Bearings are lubricated for one year
Main Bearings are 40,000 hour type
Handles 5,000 pound Belt Loads
Out-Board Bearings and Flexible Couplings eliminated
Furnished with Single or Double Plate, Organic or Morlife® faced Gear tooth Type Clutches

Insure longer work life and reduce down-time with this NEW extra heavy-duty ROCKFORD POWER TAKE-OFF.

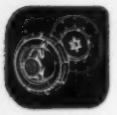
BW SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

ROCKFORD Clutch Division BORG-WARNER
1303 Eighteenth Ave., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.


Small Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc


Heavy Duty Over Center

Power Take-Offs

Speed Reducers

CLUTCHES

BJ SWABS

- More swabbing for your money
- Free falling
- Choice of two rubber designs
- Rubbers last longer
- Disc-type dumps overloads
- Simple four-part design
- Positive seal

Sold through supply stores

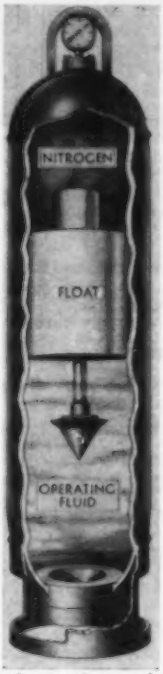
Byron Jackson Tools, Inc.

A SUBSIDIARY OF BORG-WARNER CORPORATION

Los Angeles Houston

New Equipment

Pressure Accumulator and Pulsation Dampener



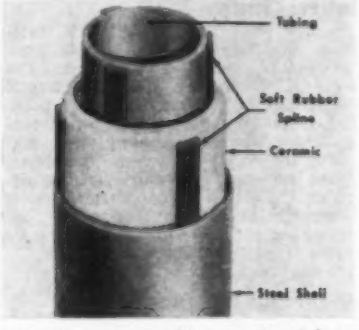
An accumulator built especially for installations where high discharge velocity is a requirement has been introduced by Payne Manufacturing Company. A free-moving float takes the place of rubber bladders or diaphragms. This model uses an oversize removable shut-off valve which seats first on a Hycar rubber element and then effects a metal-to-metal secondary seal. Nitrogen precharge is positively retained, and there is no vortex effect.

Sizes range from 1 to 20 gal with working pressures from 2000 to 6000 psi. Any volume is available with multiple units. Standard models will handle a variety of fluids, including water, oil, distillate, mud, and certain chemicals. Accumulators made of special materials for other fluids are available. *Payne Manufacturing Company.*

Circle number (14) on reply card.

Protective Joint for Dual Completion String

Tubing replacement due to high pressure gas-jetting opposite perforations in multiple completions is said to be virtually eliminated by a new protective joint, called Impenecap, manufactured by Plastic Applicators, Inc. Material used in the joint is an extremely dense, silica-base ceramic composition harder than topaz,



corundum, or sapphire, testing 9.2 on Mohs' scale. Its method of application employs a steel outer shell with soft rubber splines between tubing, ceramic and shell. In effect, the ceramic floats on a cushion of rubber between 2 surfaces of steel, protected against impact and isolated from vibration and shock.

The joint is manufactured in standard 30 ft lengths. For lengths greater than 30 ft, special box and pin joints are furnished to make up sections of any length. Standard joints are built around 2⅜-in., N-80 tubing. *Plastic Applicators, Inc.*

Circle number (15) on reply card.

BJ SWABS

- Pull more fluid
- Faster falling
- Rubber designs interchangeable
- Self-adjusting to loads
- No ball & seat to clog
- New field-proved principle
- Only two rubbers needed

Sold through supply stores

Byron Jackson Tools, Inc.

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Los Angeles Houston

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Drilling-Producing Literature

Vertical Set Oil Tools Brochure

Knowlton Oil Tool Company presents its line of packers, hangers, and anchors in an 8-page illustrated brochure which includes photographs and drawings of the various tools and explains the patented setting slot used in all the tools. This setting slot permits setting and release of all 13 tools with vertical movement only. *Knowlton Oil Tool Company.*

Circle number (17) on reply card.

Condensed Valve Catalog

The Ohio Injector Company has published a new condensed version of its general catalog which lists its complete line of industrial valves. Face to face dimensions are supplied in full size ranges. The catalog lists a section on bronze brazed joint valves as well as the nickel-iron line.

A forged and cast steel section shows valve trim designations and pressure-temperature charts with ratings to latest ASA specifications. *The Ohio Injector Company.*

Circle number (18) on reply card.

Plunger Brochure

Camco has published a 4-page brochure which illustrates the company's Type A plunger. The brochure includes a cutaway drawing of the plunger, descriptions of the application, design, construction, and operation of the plunger, and a table of specifications for the 2-in. and 2½-in. sizes. *Camco, Inc.*

Circle number (19) on reply card.

Plastic Piping

A 3-page engineering data bulletin dealing with a new plastic piping material known as Type II ABS has been released by Southwestern Plastic Pipe Company. The bulletin lists physical and mechanical properties, chemical resistance data, flow characteristics, and working pressure charts for the pipe, which is offered in 4 pressure ratings. *Southwestern Plastic Pipe Company.*

Circle number (20) on reply card.

Packer Retriever for Drillable Packers

A 4-page folder describing a packer retriever, a new tool which offers a safe measure for retrieving drillable production packers, is available from Bowen Itco. The folder covers the tool's use and advantages, with illustrations of the tool in operation, sectional drawings, and complete instructions for release and resetting procedures. *Bowen Itco, Inc.*

Circle number (21) on reply card.

Treatment of Water for Secondary Recovery

Buckman Laboratories, Inc., has prepared a bulletin entitled "Busan 881 for Microorganism Control in Secondary Recovery Waters." The bulletin is a complete lab report on applications of the chemical and includes a nomograph for determination of correct treatment. *Buckman Laboratories, Inc.*

Circle number (22) on reply card.

Standby Engine Starter Package

A bulletin published by C & D Batteries, Inc. describes operation of the manufacturer's new combination power package of silicon charger and lead-calcium plate batteries. Requiring virtually no maintenance, the compact charger-battery combination can be installed in minimum space alongside standby emergency power engines.

Bulletin explains performance of both charger and battery. Curves and diagrams illustrate discharge and charging characteristics of the combination from the time the engine demands starting power until the battery reaches full charge again. *C & D Batteries, Inc.*

Circle number (23) on reply card.

Book Covers Roller Chains

A new book on precision steel roller chains and sprockets is available from Link-Belt Company and contains 154 pages of engineering data illustrating a wide range of roller chain applications. The book contains typical installation conditions, formulas, charts, and diagrams to simplify selection of proper chains for any application. It also describes the selection, application, installation, lubrication, maintenance of roller chains and sprockets for drives and conveyors. *Link-Belt Company.*

Circle number (24) on reply card.

Well Anodes for Cathodic Protection

Well Anode Division of Petroleum Instrument Company has published a 4-page brochure describing the company's line of well anodes for wells making salt water. Special anode fittings, engineered for down-hole installation, prevent corrosion of casing, tubing, screens, liner, packer seats, pump and gas lift equipment, flow lines, etc. The brochure illustrates applications of the various zinc or magnesium anodes and includes tables of size ranges available. *Well Anode Division, Petroleum Instrument Company.*

Circle number (25) on reply card.

Two-Zone Pumps

A new 8-page brochure on 2-zone pumps is now available from the Axelson Manufacturing Company. The brochure includes the 3 basic 2-zone pump configurations, consisting of 2-packer single string, 1-packer double string, and 1-packer triple string. Features, specifications, schematic drawings of pump operation and renderings of the cross-over assemblies are described and illustrated in the brochure. *Axelson Manufacturing Company.*

Circle number (26) on reply card.

All-Metal Cementing Equipment Described

A new catalog describing all-metal shoes and collars and other cementing equipment manufactured by Rector Well Equipment is announced. Illustrated with photographs and cutaway drawings, the catalog includes operating and performance data on cementing shoes and collars, 2-plug stage cementer, cementing head, and other special equipment. *Rector Well Equipment Company, Inc.*

Circle number (27) on reply card.

10,000 psi Blowout Preventer Bulletin

Shaffer Tool presents the complete story of its new XHP line of blowout preventers rated to 10,000 psi in a 12-page bulletin. The publication includes description of the construction and operation of the preventers as well as a tabulation of assemblies, parts, and specification data. Also included are dimensional and engineering data and illustrations of hydraulic fluid circuits, lubrication system, and torque specifications for bolts and studs. *Shaffer Tool Works.*

Circle number (28) on reply card.

NMR Core Analysis

Measurement of oil and water in geological cores (sand and dolomite) by the Model 104 nuclear magnetic resonance (NMR) analyzer is described in a report available from Schlumberger. The report covers sample preparation, testing procedures and computations, results achieved and curves that were attained. Measurements by the analyzer required from 30 seconds to 2 minutes. *Schlumberger Well Surveying Corporation.*

Circle number (29) on reply card.

Catalog of Adsorption Units

A new catalog published by Parkersburg gives complete operating details on the Dynamic Adsorption Unit (DAU) designed and manufactured by that company. Included are graphic diagrams showing typical applications of DAU Type I Weldrier for dehydration and of the DAU Type II Welsorber for dehydration and hydrocarbon recovery. *The Parkersburg Rig & Reel Company.*

Circle number (30) on reply card.

LACT Unit Brochure

A new 8-page brochure has been prepared by Murdock Custody Transfer Systems to present its line of LACT systems. The brochure includes lists of components, schematic flow diagrams, operating cycles and specifications of the O.W.G. treaters used in the systems. *Murdock Tank and Manufacturing Company.*

Circle number (31) on reply card.

the Refining Engineer

Refining
Petrochemical
Gas Processing

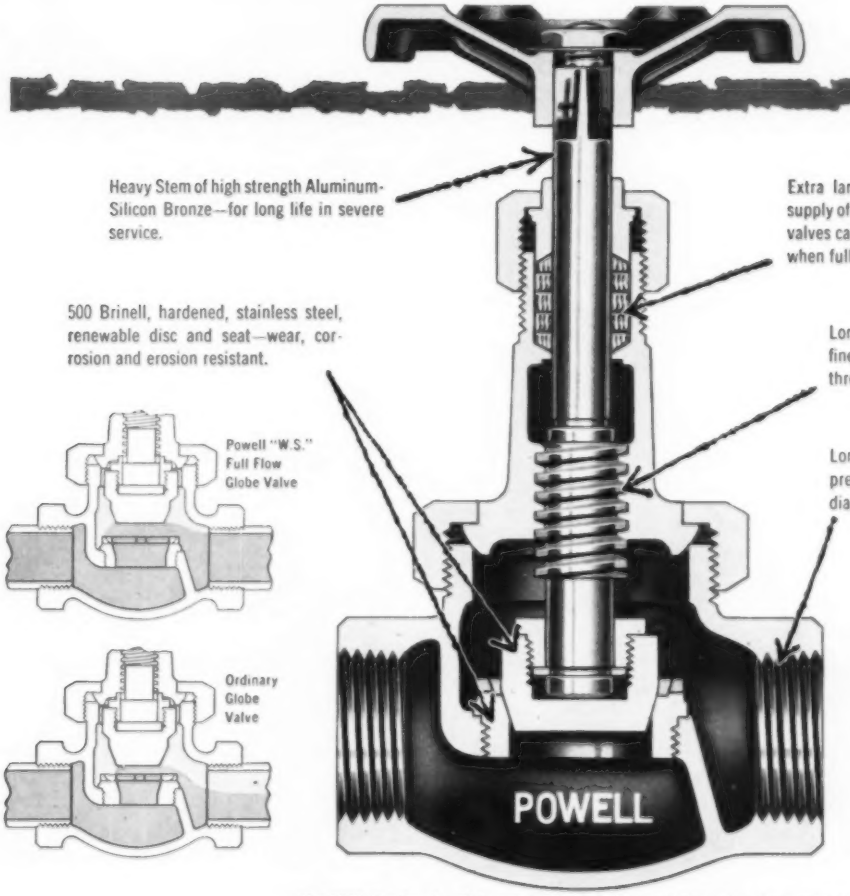
BULLETIN!

POWELL introduces new member in world's largest family of valves

Powell engineered "Full Flow" bronze valves are now available in a full line: the brand-new 150-pound screwed end Globe Valve, in addition to the well-known 200-300 pound Screwed and the 150-300 pound Flanged Globe and Angle Valves.

Although designed by Powell to assure maximum flow with minimum pressure drop and internal turbulence, these valves can be throttled to permit only the minutest amount of fluid to pass through. And, if desired, they can be supplied with Indicator Collar, Arm and V-port Disc for quickly determining flow and holding it constant.

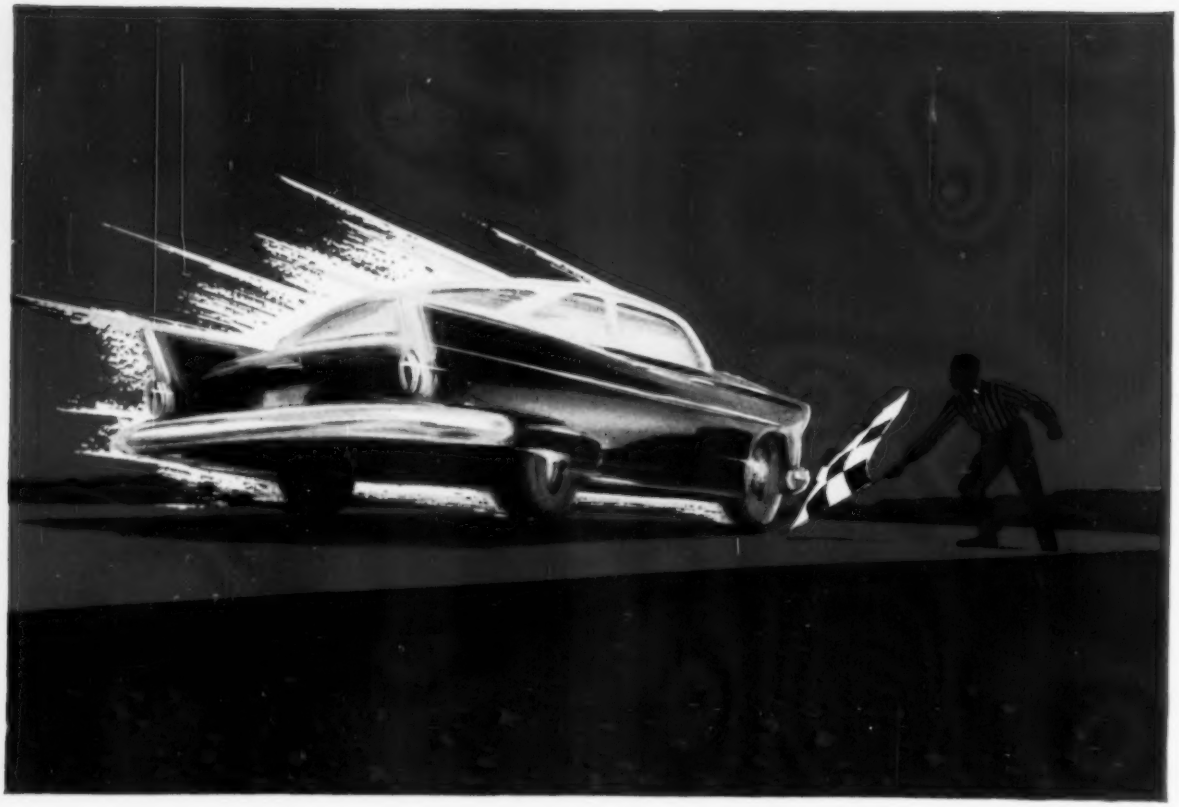
Compare these advantages of Powell Full Flow valves:


Heavy Stem of high strength Aluminum-Silicon Bronze—for long life in severe service.
Extra large stuffing box holds ample supply of lubricated asbestos packing—valves can be repacked under pressure when fully open.
500 Brinell, hardened, stainless steel, renewable disc and seat—wear, corrosion and erosion resistant.
Long Acme Stem Threads have a fine pitch to easily regulate the close throttling and reduce thread wear.
Long pipe thread and thread run-off prevent jamming the pipe against the diaphragm and distorting the seat.
POWELL

When you require precise flow control with minimum pressure drop and turbulence, little maintenance and long life, specify Powell Full Flow Valves. Consult your local distributor, or write us for illustrated literature.

Fig. 2600 (Sectional)—150-pound "W.S." Full Flow Globe Valve, Screwed Ends

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**



For those new, higher compression engines...
a new Catforming catalyst

The trend to higher compression engines is here to stay. And wide-awake refiners have to produce fuels to suit these up-to-the-minute engines.

Atlantic is proud to offer an advanced Catforming catalyst designed to economically produce higher octane gasolines . . . *and it can be utilized in your present equipment.* For more information, write, wire or call The Atlantic Refining Company, P. O. Box 8138, Philadelphia 1, Pennsylvania.

Higher gasoline octanes through Pentafining

You can convert the low-quality n-paraffins (C_5, C_6, C_7) in your gasoline pool to high octanes! Pentafining, the process developed by The Atlantic Refining Company, makes it possible. For full particulars, write today to The Atlantic Refining Company, P. O. Box 8138, Philadelphia 1, Pennsylvania.

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ATLANTIC

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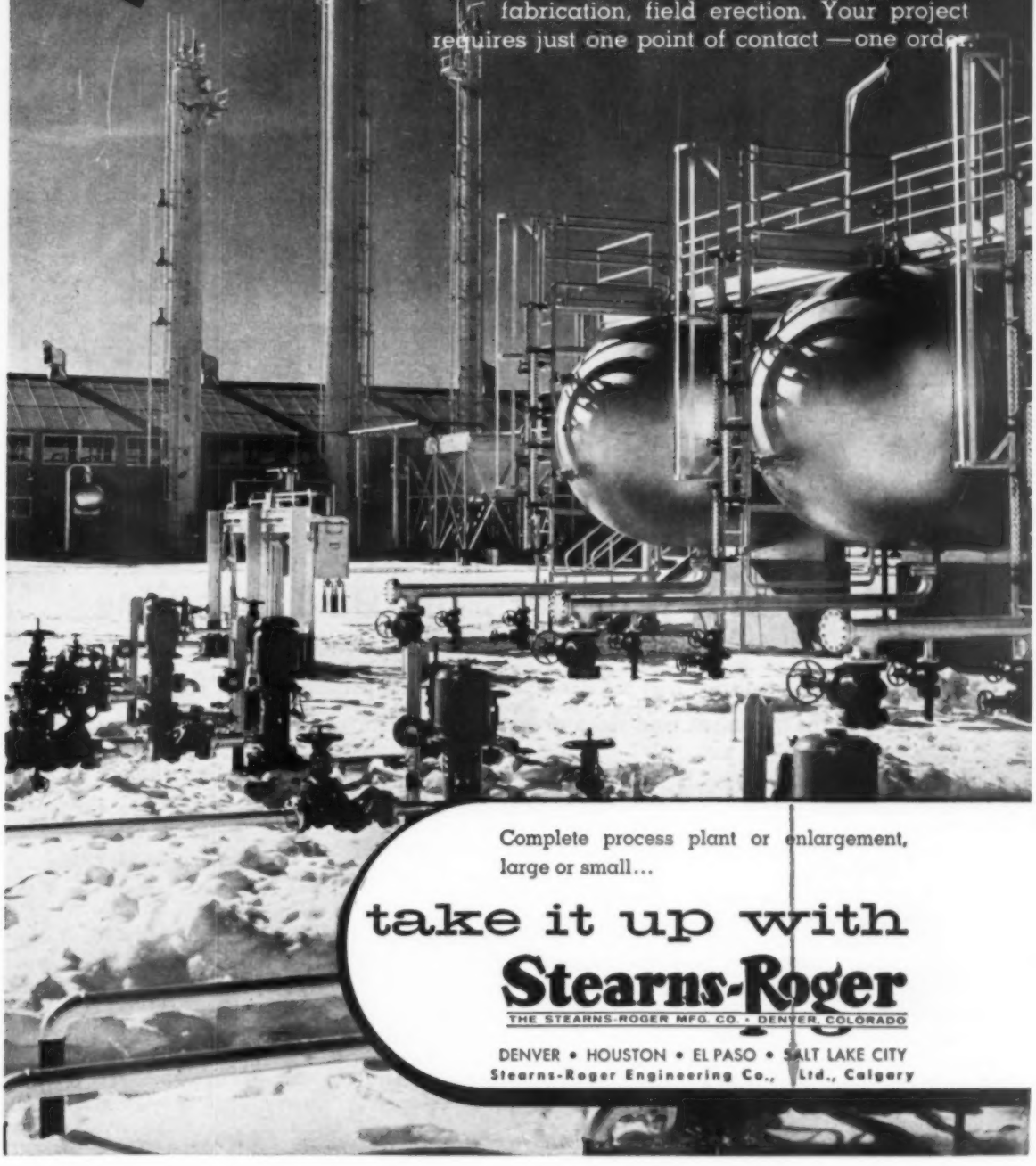
winterizing...

is a Stearns-Roger specialty

Every "cold country" plant designed and built by Stearns-Roger provides efficient, economical operation with the necessary protection for operators and equipment. The experience of more than 25 years goes into every cold climate plant... design, engineering, procurement, fabrication, field erection. Your project requires just one point of contact — one order.



Complete process plant or enlargement, large or small...

take it up with

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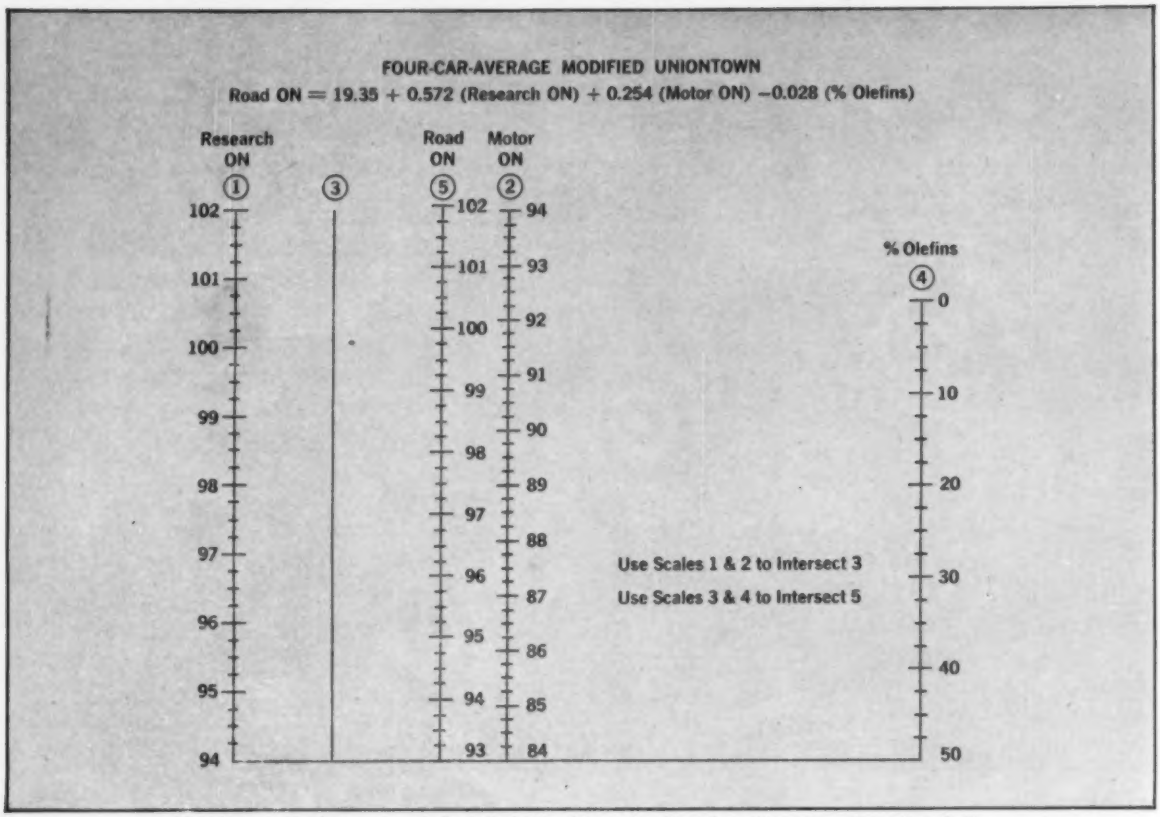
THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO

DENVER • HOUSTON • EL PASO • SALT LAKE CITY

Stearns-Roger Engineering Co., Ltd., Calgary


FOUR-CAR-AVERAGE MODIFIED UNIONTOWN
Road ON = 19.35 + 0.572 (Research ON) + 0.254 (Motor ON) −0.028 (% Olefins)
Research ON
Road ON
Motor ON
% Olefins
Use Scales 1 & 2 to Intersect 3
Use Scales 3 & 4 to Intersect 5

Here is an example nomograph for calculating the road antiknock performance of premium fuels.

Ethyl Research establishes new equation coefficients for calculating road octane numbers of 1958 gasolines

Now, road performance can be predicted for both premium and regular fuels, without the expense and time ordinarily used in road-rating programs

LAST YEAR Ethyl Research Laboratories in Detroit developed a system for calculating road performance of premium fuels from routine laboratory tests.

The work was based on a study of samples, from refineries, representing 75 per cent of the premium motor fuel blended in the United States during 1957.

Extensive computer analyses of test data resulted in a general equation with coefficients that can be selected to cover (1) different makes of cars; (2) Modified Uniontown road ratings; and (3) Modified Borderline road ratings at various speeds.

Ethyl Research has now completed the work of bringing these equation coefficients up to date so that road performance of premium and regular fuels can be calculated for a number of 1958 passenger cars.

A Road Performance Equation

Road performance of gasolines can be calculated from this equation:

$$Y = a + bR + cM + dO$$

where Y = Road octane number
R = Research octane number
M = Motor octane number
O = Per cent olefins
and a, b, c, and d are equation coefficients for a particular car and test.

Coefficients for 1958 Cars

Two publications are available to the refining industry.

They are "Road Octane Correlations for Premium Gasolines 1958," covering tests made on four representative cars, and "Road Octane Correlations for Regular Gasolines 1958," covering tests made on three representative cars.

Appropriate coefficients (a, b, c, and d) are reported for each vehicle to facil-

itate calculation of both Modified Uniontown and Modified Borderline (various speeds) road antiknock ratings.

Also included in each report are average coefficients.

Example coefficients and other pertinent information are shown below for a typical 1958 car. (Table I)

Limitations of Equations

Experience with these equations has shown that their use should be restricted to fuels of similar antiknock qualities and hydrocarbon composition to those used in the original program.

This restriction still allows wide latitude of use, however, since full-boiling commercial gasolines representing current grades were used. (Table II)

Although the road octane numbers assigned to gasolines by one vehicle are not necessarily reproducible in other vehicles of the same make and model, experience has shown that *relative* fuel ratings tend to be quite consistent from car to car.

Ideally, therefore, the equations should be used to compare the road performance of gasolines rather than using them to calculate the road octane number of a specific fuel.

The same reasoning also applies to experimental road-rating results.

TABLE I

Equation Coefficients for a Typical 1958 Car

Road ON = a + b (Research ON) + c (Motor ON) + d (% Olefins)

	a	b	c	d	Std. Error
Modified Uniontown	30.75	0.458	0.263	-0.034	0.36
Modified Borderline					
1650 rpm	27.11	0.637	0.111	-0.029	0.48
2000 rpm	23.57	0.491	0.302	-0.022	0.38
2500 rpm	29.50	0.495	0.229	-0.038	0.32
3000 rpm	22.75	0.498	0.289	-0.047	0.36

Octane Number Requirements

	Modified Uniontown	Modified Borderline 1650 rpm	2000 rpm	2500 rpm	3000 rpm
Primary reference fuels	95.9	96.1	94.4	93.3	92.8
Commercial reference fuels	96.5	96.8	95.0	94.3	95.0

TABLE II

Range of Full-Boiling Premium Fuels

Research Octane Number	96-102
Motor Octane Number	85-94
Sensitivity (RON minus MON)	7-14
TEL, ml per gallon	2.0-3.0
Hydrocarbon Type, vol %	
Olefins	5-50
Aromatics	5-50
Saturates	40-80

How Ethyl Research is helping you

In recent years interest has been continuous within the Oil Industry for effective means to calculate road antiknock performance of gasolines.

As a result Ethyl has two current publications directed toward this interest.

1. "Road Correlations for PremiumGasolines1958."
2. "Road Correlations for Regular Gasolines 1958."

These publications are one more example of Ethyl's continuing service to the Oil Industry. Copies can be obtained from your Ethyl Representative or by writing Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

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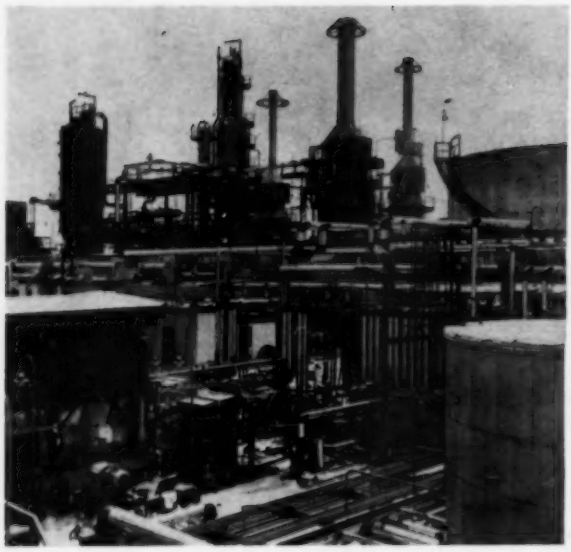
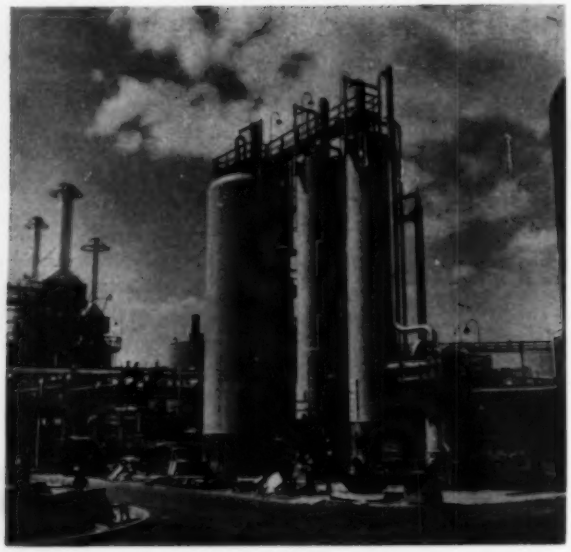
ETHYL CORPORATION
New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.



Process Area, Showing Columns and Heaters During Final Clean-up. From left to right are the vacuum and atmospheric columns and the vacuum, atmospheric and heat medium heaters.



These Asphalt Oxidizers are Designed for Continuous or Batch Service. The larger unit is rated at 1000 barrels, while the smaller units handle 250 barrels each.

Cities Service Places

MODERNIZED ASPHALT REFINERY ONSTREAM

D. B. Pruess
Superintendent, Manufacturing
Cities Service Oil Company
New York, New York

A SPANKING NEW ASPHALT REFINERY is now in full operation for Cities Service Oil Company, located on Staten Island Sound in Linden, New Jersey. The company has been a major supplier of asphalts manufactured at the Linden plant for many years. Products include penetration and cutback paving grades, roofers' fluxes and a diverse line of industrial specialties, both steam-reduced and oxidized. Products are shipped by tank car, tank truck, and water, with the bulk of the output going to customers in New Jersey, New York, and Pennsylvania. Shipments of many specialty grades move, however, over a much wider area.

Older Process Units Replaced

Prior to the recently-completed modernization, principal processing facilities consisted of two atmospheric distillation units, rated at 7000 bbl per stream day each, and nine direct-fired horizontal oxidizing stills. One small heater was available for keeping some of the more critical products at a satisfactorily high temperature. Otherwise, the asphalts in storage were heated by 100-lb steam. Market and economic studies indicated continued long-term asphalt demand at high levels and that modernization of the plant, with the objectives of outstanding product quality and customer service, could be justified.

The plant, designed and constructed by C. F. Braun & Co. with Cities Service personnel collaborating in some areas of process design, is engineered to produce 400,000 tons a year of paving and industrial asphalts. Critical components of the distillation unit are sized, however, to permit expansion to 500,000 tons annually of output, with minimum added investment costs.

New facilities include a two-stage distillation unit, a gasoline column for solvent production, treating facilities for solvents and gasoline, three vertical oxidizers, and asphalt blending, storage and shipping facilities. Principal auxiliary units are a new steam plant and a circulating hot oil system for heating asphalts.

Crude Distillation Unit Design

Crude distillation unit consists of atmospheric and vacuum sections and a finishing section for solvents and gasoline. It is designed to process 14,000 bbl of crude oil per day. Motor-driven pumps, located at the tank farm, deliver the crude (normally of Venezuelan or Mexican origin) to the turbine-driven charge pumps at the unit. The crude picks up heat from the No. 2 fuel and No. 4 fuel product streams and from circulating reflux on the way to the desalter. This unit is the electrostatic type.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Some of the heavier crudes processed require dilution with naphtha to reduce specific gravity in order to facilitate the separation of water from oil in the desalter. Following the desalter, the crude passes through two more exchangers, acquiring further heat from the top side-stream and the asphalt bottoms of the vacuum unit. Then the crude enters the heater.

From the atmospheric heater, a vertical-flow unit, the crude goes to the atmospheric column. Light naphtha is taken from the top of the tower; that not required for reflux is pumped to the gasoline column. Product side streams of Stoddard solvent, No. 2 fuel oil and No. 4 fuel oil are removed as side streams. A circulating side-stream is taken between the Stoddard solvent and No. 2 fuel draw-offs and returned to the tower after reduction of heat by cooling and exchange.

Vacuum Tower Operation

Atmospheric tower bottoms are pumped directly to the vacuum section heater. It, too, is a vertical-flow unit from which topped crude discharges into the vacuum column. Column pressure will range from 50 to 130 mm of mercury, depending upon crude and operation. Vacuum is maintained by surface condensers and steam ejectors. Two sidestreams are taken. Part of the upper is withdrawn as No. 4 fuel oil product.

Balance is split between intermediate reflux and a pumparound stream introduced near the top of the tower to reduce load on vacuum equipment and minimize oil carryover. Lower sidestream is withdrawn, after stripping, as a heavy gas oil or "black oil" utilized in asphalt formulations. In some cases it is recycled with the reduced crude charge to the vacuum heater to reduce coke formation on trays. Asphalt product is withdrawn from the column bottom.

Separation of asphalt by vacuum distillation yields closely-fractionated products of high flash point. Cracking the asphalt with consequent adverse effect on quality is avoided. Process is extensively instrumented to assist plant operators in maintaining accurate and continuous control of product quality.

Naphtha and Solvent Processing

Overhead naphtha from the atmospheric column is separated, in the gasoline column, into two products. They are gasoline and 140-IBP solvent or 240-IBP solvent. Feed is heated by exchange with the hot tower bottoms. A steam heated reboiler supplies heat to the tower at the bottom.

Gasoline and solvent pass through separate caustic-wash drums for hydrogen sulfide removal. From these the solvent is pumped to storage, and the gasoline to the Bender treater. Gasoline is sweetened continuously in the latter unit, the mercaptans being converted to disulfides in presence of a lead sulfide catalyst. Sweet gasoline is water-washed on the way to storage.

Oxidizers are Batch or Continuous

In the oxidizing plant air is blown through hot straight-run asphalts to yield products with new properties. Oxidized asphalts have higher melting-points and lower penetrations as well as different melting-point-penetration relationships than asphalts from which they were made.

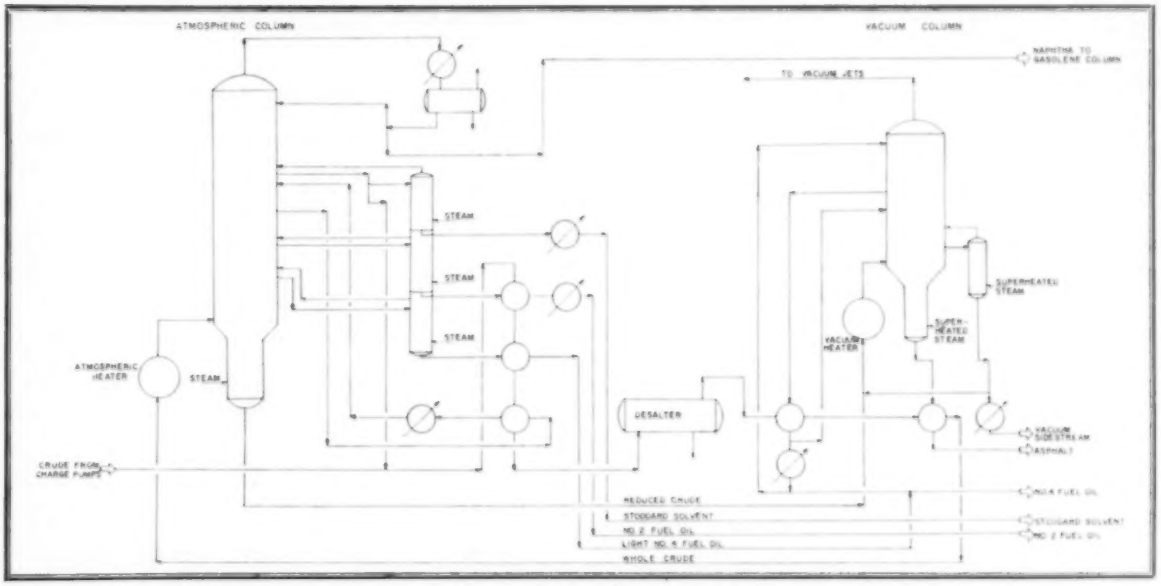
There are three vertical oxidizers. One, for large volume grades, has a capacity of 1000 bbl. The other two are 250-bbl units for smaller batches. The 1000-bbl unit is designed for batch or continuous operation; smaller ones are primarily for batch operation.

Feed to the oxidizers is normally heated by exchange with circulating hot oil. Each of the vessels has spargers near the bottom for the introduction of air and steam. Two large blowers and one smaller one, having a combined capacity of 4600 std cu ft per min, provide the air. They are manifolded by a common header to provide flexibility of operation. Asphalt oxidation is exothermic. Each unit has a proportioning-type pump to inject water into the oxidizing-air stream as a means of controlling the temperature of the asphalt and thus the quality of the product. Vapor from each of the oxidizers passes through a water-cooled condenser mounted in a knockout drum. Recovered condensate is burned as fuel.

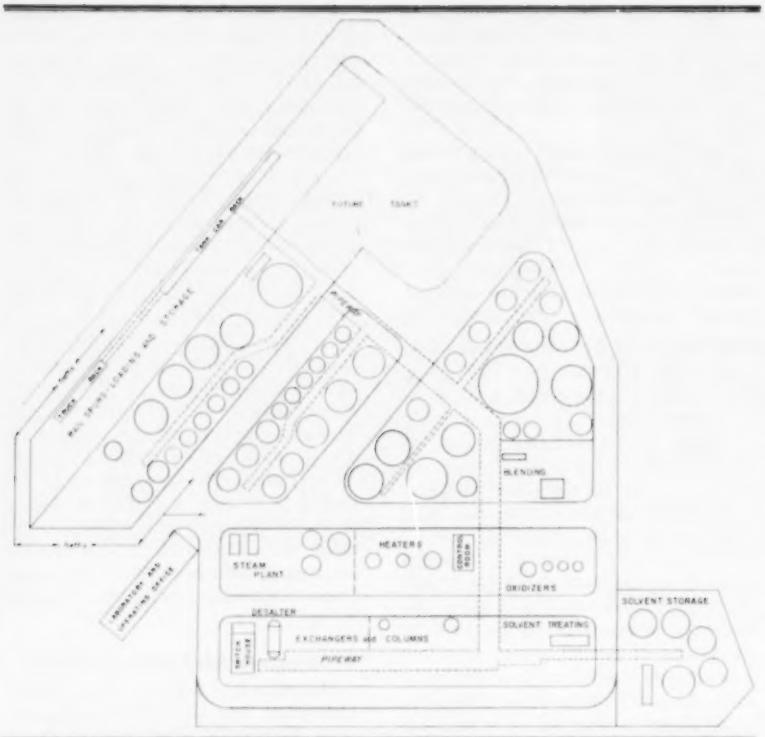
Continuous Blending Facilities

Blending area has four automatically controlled, continuous blending stations. One each is for solvent blending, asphalt blending, high-flash cutback blending, and low-flash cutback blending. Asphalt blending station can be used to prepare oxidizer charge stocks.

In asphalt and cutback blending operations a displacement meter measures rate of flow of total outlet stream. A second meter measures rate of flow of one of the component streams. Each meter transmits a signal to a flow-ratio controller. This instrument maintains a



Flow Plant for Cities Service's New Asphalt Distillation Facilities at Linden, New Jersey.



Storage Tanks and Shipping Facilities are Laid Out to Provide Rapid Handling of Truck Traffic. Functional layout of process equipment, auxiliaries, and offices is also provided.

constant ratio between the total outlet-flow rate and the inlet-flow rate.

Control of solvent blending differs in that the instruments maintain a constant ratio between the two inlet streams. High-flash and low-flash cutbacks are cooled in separate air-cooled heat exchangers before being pumped to storage.

Tankage Arranged for Efficiency

Solvents — both plant-produced and purchased — used for blending cutbacks are stored in a segregated group of tanks located in a diked area.

Forty-seven asphalt product tanks have been installed. Sizes range from 600 to 20,000 bbl. Total capacity is 153,000 bbl. The tanks closest to the oxidizers and blending area store base grades, oxidized grades, and roofers' flux. Tanks further from the oxidizers store cutbacks, oxidized products, and pavers.

Seventeen of the tanks are elevated to permit gravity loading into tank trucks. Lines are sized to make it possible to load in about five minutes. Roofers' fluxes and most of the oxidized grades are in elevated tanks. An additional 10 loading spots are provided for loading trucks by pump. Loading time at these spots runs from 5 to 15 minutes. The 27 truck loading stations and plant road system are designed to make it possible for trucks to spot and load rapidly and exit from the area without delay. Five tank car loading spots are available.

Centrifugal pumps are used for solvents, cutbacks and heavy gas oil. Base grade asphalts, pavers and oxidized products are handled with rotary gear pumps.

Steam Generation and Handling

Steam at 150 psig is generated in two 40,000 lb per hr boilers equipped with automatic electric controls to adjust the draft and firing rate to hold constant steam pressure. The 150-lb steam is used in processing, for operating vacuum jets, for turbines, for cutback storage tank heating and as smothering steam. A 30-lb steam system is supplied by turbine exhaust and by reducing from the 150-lb mains. This steam is employed for heating crude and heavy fuel tanks and for the boiler water dearator. Feedwater is zeolite softened, followed by sulfite and phosphate treatment.

Hot Oil Heat Medium System

A heat medium system provides a high temperature heat source for heating oxidizer feed and for keeping stored asphalt highly fluid for quick loading. Medium employed is Cities Service 95-VI neutral oil of 100 SSU viscosity.

Circulating pumps pick up oil returning from the process or storage areas and pump it to a vertical-flow heater where temperature is raised to about 560 F. The heated oil then returns to process or to tank heating coils.

An expansion chamber — floating on the return line just ahead of the circulating pumps — absorbs changes in volume of oil in circulation as usage changes. It also minimizes amount of hot oil exposed to air. Excess oil in the system flows from the chamber to the main 10,000-gal storage tank. Oil deficiency is made up automatically from main storage tank.

Cooling Water Supply

Vertical centrifugal pumps deliver water from Staten Island Sound to the plant's cooling water system. Water is chlorinated and filtered through an automatic self-cleaning unit. Utility and instrument air comes from a central compressor. Instrument air is filtered and dried in semi-automatic regenerative driers. A stand-by steam driven compressor supplies instrument air in case of power failure.

New Service Facilities

Other construction and modernization activities being carried out under Cities Service direction include a new scale house and modification of the scale to speed up weighing and delivery of shipping papers; a plant office; a change house and lunch room; renovation of rail trackage and plant roads outside the process area; removal of the laboratory to a building adjacent to the latter area, and a mechanical shop and warehouse. Old processing units and tankage and other facilities no longer to be used will be dismantled.

Plant Now in Full Operation

The steam plant and heat medium system were activated late in May. Shortly afterward oxidizer operations began on charging stocks made in the old plant but stored in the new tankage. Distillation unit began processing crude late in June. Startup was smooth and plant has functioned exceptionally well from the capacity-design standpoint as well as with regard to product quality. ★ ★ ★

About the Author . . .

D. B. Pruess *graduated from Iowa State College with a BS in chemical engineering.*

He has been employed by Cities Service Oil Company since 1930. He served as supervisor at the company's Ponca City refinery and worked in the engineering and manufacturing department in Tulsa and Bartlesville.

In 1949 Pruess became staff executive in New York, where he was principally concerned with lubricating oil and petrochemical operations.

Since February 1957 he has been superintendent of manufacturing for Cities Service.

PHENOL and ACETONE via CUMENE HYDROPEROXIDE

Part 2: Chemistry of the Process, Operating Variables, and Product Recovery

Peter W. Sherwood, *Chemical Engineer, White Plains, New York*

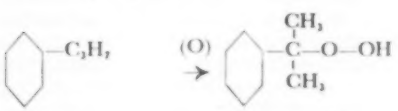
FEEDSTOCK IN the CHP route to phenol-acetone is cumene, formed by the reaction between propylene and benzene. This alkylation step originally acquired importance in the manufacture of cumene as blending stock for aviation gasoline during World War II. Technical experience acquired in this connection now serves in the production of cumene as feedstock for the cumene hydroperoxide process.

Three techniques are employed today to carry out the isopropylation of benzene: (1) Vapor-phase conversion, using orthophosphoric acid on Kieselguhr as catalyst; (2) liquid-phase alkylation in the presence of sulfuric acid; (3) liquid-phase alkylation in the presence of aluminum chloride. Details of these methods have been reported elsewhere[1, 2] and need not be repeated in this place.

Conversion of cumene to phenol and acetone takes place in two reaction steps: Autoxidation to cumene hydroperoxide and decomposition of this intermediate to phenol and acetone. This article provides technical information on each of these conversions and on methods employed for purification of the products.

Autoxidation of Cumene

Cumene, received from the alkylation plant, enters the first stage of the phenol synthesis proper; conversion to cumene hydroperoxide:



Cumene — Hydroperoxide Cumene . . . . (1)

Somewhat obscurely, the term "autoxidation" is commonly employed in referring to reactions of this type in which hydrocarbons are oxidized by molecular oxygen.

Reaction (1) is mildly exothermic (328 Btu per lb cumene hydroperoxide formed). It is carried out in the liquid phase through which the gaseous oxidizing agent is passed.

The choice of oxidizing agent is between air and purified oxygen. Armstrong[3] reports that the use of oxygen permits higher conversion rates (though, as Fortuin[4] has shown, this advantage disappears as the *maximum* rate of conversion is reached). Beyond that, purified oxygen has the advantage of carrying less cumene from the reactor and of permitting higher throughput per unit reactor volume. On the credit side for the use of air are its lower cost and the reduced danger of forming an explosive mixture with cumene.

Regardless of the oxidizing agent selected, autoxidation of cumene is characterized by low conversion rate. The problem is twofold. There is an initial incubation period during which oxidation rate is quite negligible. Once the reaction has started, it proceeds at fairly constant velocity until cumene hydroperoxide exceeds approximately 40 percent. However, this rate, too, is quite slow, ranging from three to seven percent per hour. Accordingly, there has been considerable work directed toward speeding up the reaction.

Reaction variables. The incubation period is unquestionably related to the chain mechanism of the reaction which necessitates the presence of hydroperoxide in the system. In batch processing, this problem can be side-stepped by recycling enough product to ensure a hydroperoxide content of about three weight percent at the start of the reaction. In continuous operation, which is practiced commercially, fresh cumene is continually fed to the peroxide-containing reaction system so that a constant rate of reaction can be maintained without product recycle.

Further influencing the length of the incubation period as well as the subsequent rate of oxidation is the presence of a variety of contaminants which act as reaction inhibitors. Most harmful is the presence of sulfur compounds; it is therefore essential that the cumene feed be prepared from sulfur-free benzene and propylene. Also objectionable is the presence of phenol, styrene, and methyl styrene, all of which have deleterious effect on the reaction in concentrations as low as 50 ppm. Since these last-named contaminants are formed in the course of the oxidation reaction, it is necessary to remove them almost quantitatively from recycle cumene as well as from make-up hydrocarbon feed.

Several methods of pretreatment are at hand to provide the necessary degree of hydro-carbon purification. Among them, interest attaches to pretreatment with alumina[5]; with sulfuric acid followed by metallic sodium[6]; and with sodium permanganate, sodium hydroxide or sodium bisulfite.

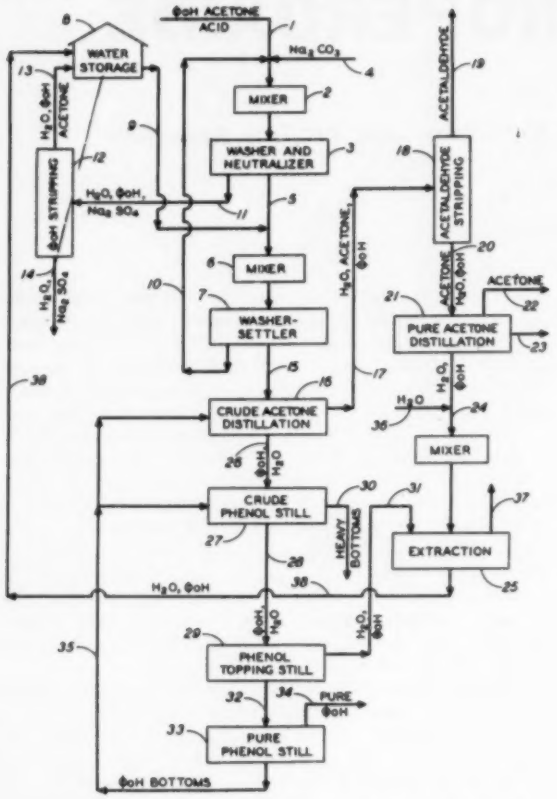
Various methods of pretreatment have been evaluated by Fortuin[4] who obtained best results by washing the cumene feed thoroughly with concentrated sulfuric acid followed, in some cases, by scrubbing with five percent aqueous mercuric acetate.

If air is employed as oxidizing agent, it should be freed of carbon dioxide by washing it with caustic solution.

Conversion rates. Using carefully purified cumene as feedstock, average conversion rates range from 3 to 13 percent per hour. Determining factor is the technique employed in carrying out the oxidation reaction. The highest reported hourly rate is formation of 11-13 wt percent of cumene hydroperoxide, obtained by oxidation of cumene at 248 F in the presence of metallic copper, which has been pretreated with nitric acid.[4] Despite the relatively favorable rate of product formation, this process does not appear to

have found commercial application. This is reportedly due to frequent operating disturbances which are traceable to the sensitivity of the reaction to the state of the copper surfaces.[5] Reaction rate obtained in commercial oxidation techniques is between five and seven percent per hour.

FIG. 2. Flow plan and typical stream compositions for purification of phenol and acetone from the CHP process.



Parts by weight per hour		Parts by weight per hour	
Line 1	242	Line 35	21
Line 4	58	Line 36	25
Line 9	214	Line 30	20.5
Line 19	0.8	Line 31 (top)	29
Line 22	55	Line 33	94
Line 23	56	Line 14	87
Line 24	49		

At the outset of the reaction, yield of hydroperoxide is nearly quantitative. As conversion of cumene proceeds, however, decomposition and other side reactions take their toll and reduce the efficiency of hydroperoxide formation. To a large extent this decline in efficiency is traceable to product decomposition which is catalyzed by small amounts of carboxylic acids formed in the course of reaction.

To offset this effect, reaction is universally carried out in the presence of sufficient alkali to neutralize byproduct acids as they are formed. Optimum conditions are found to be at a pH of 8.5 — 10.5. Oxidation in the presence of an aqueous phase can be controlled at the proper alkalinity by use of sodium carbonate. In an alternative technique, in which the liquid phase is essentially homogenous, better control of alkalinity and therefore of yield as well as of conversion rate is achieved by the use of sodium carbonate together with an oil-soluble salt such as sodium stearate.[9]

Numerous catalysts and promoters have been proposed to accelerate the autoxidation of cumene. These fall into four categories: (1) Heavy metal salts (notably oil-soluble salts of manganese, cobalt, and cerium; (2) alkaline compounds, both organic (e.g., tertiary amines) and inorganic (such as sodium carbonate); (3) pretreated metals (copper, silver); (4) miscellaneous agents (sodium chloride, barium sulfate).

There is no evidence that industrial usage extends to any catalyst excepting those in the second-named group. However, considerable effort has gone into the development of other catalysts and it behooves us to review briefly the performance and limitations of some of the more prominent of these.

In the category of oil-soluble salts of heavy metals, the greatest emphasis has been on the use of manganese, though the use of other metals — notably cobalt, cerium, and lead — has also been proposed. In fact, these salts are effective as promoters of the oxidation reaction, but they are even more effective as catalysts for the decomposition of hydroperoxides.

It is therefore necessary to establish conditions at which the oxidation proceeds at substantially higher rate than does the decomposition of cumene hydroperoxide. The controlling variable here is found to be the concentration of catalyst.

Thus, Lorand[10] reports that optimum yield is obtained by holding the concentration of manganese naphthenate between 0.25 and 0.5 percent. Bruning[12] specifies that the catalyst content should not exceed the concentration which decomposes one-tenth of the peroxide content of a mixture of 15 parts by weight cumyl hydroperoxide and 85 parts

Composition Percent by Weight.

	H_2O	Phenol	Acetone	Acetal-dehyde	Aceto-phenone	Cumene	Mesityl oxide	α Methyl styrene	Carbinol	Cumyl phenol	H_2SO_4	Salt	Heavier
Line 1	1.4	38	45	0.2	1.6	.9	1.25	3.5	1.8	3.2	0.6	—	1.6
Line 9	88	3.3	8.7	—	—	—	—	—	—	—	—	—	—
Line 11	85	2	7.9	—	—	—	—	—	—	—	—	5.0	—
Line 13	83	3.3	13.5	—	—	—	—	—	—	—	—	—	—
Line 14	87	—	—	—	—	—	—	—	—	—	—	13.0	—
Line 15	17.3	35	36.4	0.15	10.4	10.4	10.4	10.4	10.4	10.4	—	—	—
Line 17	23.6	1.6	69	0.3	5.6	5.6	5.6	5.6	—	—	—	—	—
Line 22	0.2	—	99.8	—	—	—	—	—	—	—	—	—	—
Line 23	1.0	—	99	—	—	—	—	—	—	—	—	—	—
Line 24	76.5	5.2	—	—	—	4.5	7.1	6.6	—	—	—	—	—
Line 26	9.5	73.5	—	—	2.7	—	—	3.4	2.8	5.2	—	—	2.7
Line 28	10.7	82.5	—	—	—	—	—	6.4	—	—	—	—	—
Line 30	—	19.6	—	—	20.2	—	—	—	—	38	—	—	22.6
Line 34	—	99.9+	—	—	—	—	—	—	—	—	—	—	—
Line 37	7.9	24	—	—	—	8.8	11.7	47	—	—	—	—	—
Line 38	96	2.9	—	—	—	—	0.6	—	—	—	—	—	—

of cumene at 176 F within 45 hours. This requirement limits the permissible concentration of dissolved manganese at .0012 percent.

When manganese is employed in an oil-insoluble form, it may be introduced in higher percentage. Thus, Griffin[11] calls for the use of manganese dioxide in the amount of 0.5 - 1.0 percent, based on cumene.

The use of alkaline catalysts favors yield as well as reaction rate. Mosnier[13] cites an experiment in which addition of sodium formate raised average hourly yield of cumyl hydroperoxide from 1.74 percent to 5.59 percent. Ability to accelerate the reaction is ascribed similarly to sodium carbonate.[14] Improvement in reaction rate as well as in yield has also been claimed for the use of tertiary amines, such as pyridine, as catalysts in the autoxidation of cumene.[15]

Copper (as well as silver) metal, pretreated by nitric acid has been found to be an effective catalyst for the oxidation of cumene.[4]

The emulsion technique of autoxidation is of industrial significance. This process stems from the work of Armstrong[16] and others, showing that the oxidation rate can be greatly expedited and cumene hydroperoxide formation can be greatly improved by carrying out the reaction in an emulsion of cumene with alkaline aqueous phase. The pH of the alkaline phase is held between 8.5 and 10.

To obtain the best conditions, an emulsifying agent is employed in conjunction with thorough agitation. The choice of emulsifying agent is significant, and sodium stearate has been found highly effective.

Of further importance is the volume ratio of water to hydrocarbon. As this ratio increases, the rate of cumene oxidation is improved. However, this advantage is eventually offset by the reactor volume taken up by the aqueous phase.

Operating temperature may range anywhere from 158 F to 266 F. Especially in processes where heavy metal salts are the proposed catalysts, operating temperature is normally limited to 158-185 F. The non-catalytic processes employed commercially call for operation at 230-266 F in order to expedite the reaction. Such temperatures necessitate, of course, use of elevated pressure in order that a liquid phase may be maintained.

According to Hock,[7] a number of industrial units carry out the oxidation in several successive stages at progressively lower temperature. For example, the first stage may take conversion to 10 percent hydroperoxide content by operation at 248 F. In the second stage, peroxide content is raised to 15 percent at 243 F, in the third stage to 20 percent at 239 F, and in the fourth stage a peroxide content of 27 percent is reached at 230 F. In this approach, the highest temperature is employed in the early stages where product decomposition is not yet a serious factor.

There is little evidence that pressure has any accelerating effect on the oxidation rate. Operating pressure is determined by the need to maintain liquid phase at the operating temperature of 230-266 F. The autoxidation is normally carried out at 60 to 200 psig.

As the oxidation reaction proceeds, yield-destroying side reactions occur in increasing measure. It is not feasible, therefore, to take complete conversion per pass. In commercial practice, conversion per pass is held at about 25 percent.

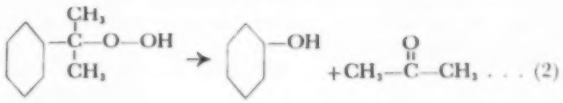
Product leaving the oxidation reactors contains about 65-70 percent unconverted cumene. It is common practice to remove the bulk of this hydrocarbon from the crude product by vacuum distillation, leaving a mixture which contains 75 percent to 85 percent cumyl hydroperoxide. Where the oxidation is carried out by the emulsion process, the cumene distillation is preceded by a phase separation step.

Cumene taken overhead must be purified carefully. It is then recycled to the oxidizers.

The crude hydroperoxide concentrate contains a number of impurities, among them chiefly unremoved cumene, as well as acetophenone, dimethyl phenyl carbinol, phenol, and alpha-methyl styrene. These byproducts do not interfere with the subsequent conversion to phenol plus acetone and the crude is therefore taken directly, and without further purification, to the plant's decomposition section.

Decomposition of Cumyl Hydroperoxide

The final reaction in the CHP process of phenol synthesis is:



(2)

Cumene Hydroperoxide — Phenol — Acetone

This conversion proceeds rapidly in the presence of strong acid. It is accompanied by the liberation of approximately 114,700 Btu per lb-mole. Adequate cooling facilities must therefore be provided — ability to remove the exothermic heat of reaction determines permissible throughput since close temperature control is essential.

Sulfuric acid is the catalyst universally employed in industrial execution of the decomposition reaction. Several techniques have been developed for contacting the hydroperoxide with this catalyst.

In an early version of the process, dilute (approximately 10 percent) sulfuric acid and feedstock are brought into intimate contact by thorough agitation. Reaction product is allowed to settle and the organic and aqueous layers are worked up separately for products recovery.

This approach has several drawbacks. Among them are the controlling effect of stirring efficiency on reaction rate; the corrosive nature of dilute sulfuric acid, and complexity of the recovery system, due to the fact that desired products (i.e., phenol and acetone) are soluble in both the organic and inorganic phases. The problem of two-phase operation is compounded by the need to dispose of a large amount of phenol-bearing waste water.

Several methods have been developed to permit execution of the decomposition reaction in single phase. In each case, one of the main reaction products is recycled to the decomposition chamber in sufficient quantity to homogenize the reaction system.

The use of phenol as homogenizer has been developed by Rhone-Poulenc.[18] In this process, a pool of phenol is maintained in the reactor. To this, cumene hydroperoxide and sulfuric acid as well as make-up phenol are added continuously. Acid concentration is 30-75 percent and its amount is about one to five weight percent of the hydroperoxide. The reaction is permitted to proceed at 122 F and feed rate is adjusted so that cumene hydroperoxide content in the mixture does not exceed 0.5 percent.

Reaction mixture passes continuously into a second vessel, also maintained at 122 F, where the reaction is completed. Effluent from this stage contains less than 0.1 percent CHP. The decomposition mixture is taken to a third vessel where the acid is neutralized to the methyl red paint with caustic soda.

The neutralized mixture is allowed to settle for removal of a small aqueous layer containing principally sodium sulfate. The organic layer is distilled in three columns. In the first of these, operated at atmospheric pressure, acetone is taken overhead, followed by topping-off alpha-methyl

styrene. Finally, crude phenol is taken off by vacuum distillation.

Yield on cumene hydroperoxide is reported to be 94-96 percent phenol and 95 percent acetone.

Use of acetone as homogenizer has been developed by Hercules Powder Company[19]; this technique is apparently in commercial use. In this process, concentrated (95-96 percent) sulfuric acid is introduced as a one percent solution in acetone. Heat control can be readily effected by refluxing acetone (at about 132.8-149 F). Cumene hydroperoxide and make-up acetone are added to a reactor containing the acetone-homogenized reaction mixture.

Here, too, it is desired to feed a crude hydroperoxide which has been concentrated to 75-88 percent by prior distillative removal of unconverted cumene. Water content of the feed should be low (preferably less than 2 percent) to prevent formation of two layers.

While the amount of sulfuric acid may be varied over wide limits, Filar[19] states that the most desirable rate of addition will furnish to the reaction medium about 0.8 wt percent SO_3.

In sulfuric acid-catalyzed decomposition of cumene hydroperoxide, operating temperature should be held between about 86 and 167 F, and preferably between 113 and 140 F. Exact level depends principally on the operating technique (single-phase vs two-phase reaction) and acid concentration. Drawback of low temperature is slow reaction rate. At high temperature, on the other hand, side reactions may take excessive toll. Most important of these side reactions is the thermal decomposition of cumene hydroperoxide, which yields acetophenone and methyl alcohol.

Conversion is normally carried out at essentially atmospheric pressure. Little is gained by choosing either higher or lower pressure at the temperatures involved.

Insofar as is known, sulfuric acid is the only catalyst employed commercially in the decomposition reaction Other catalysts which have been proposed for this purpose include phosphoric and sulfonic acids, calcium sulfate and cupric sulfate,[20] gaseous sulfur dioxide,[4] and elemental sulfur or phosphorus.[21]

Product Purification

The crude decomposition product is a fairly complex system. In addition to phenol and acetone, it contains acetophenone, dimethyl phenyl carbinol, alpha-methyl styrene, cumyl phenol, acetaldehyde, methanol, mesityl oxide, polymeric materials, the acid catalysts, and organic acidic contaminants, plus a number of trace impurities.

First step in the recovery of phenol and acetone from this mixture is neutralization of acids stronger than phenol. Subsequent purification methods differ, depending above all on whether the product is single- or two-phase. (Note that in single-phase decomposition processes, a small aqueous layer is formed during the subsequent neutralization. Phenol and acetone content of this small layer is, however, relatively insignificant.) In the course of neutralization, salt (i.e., sodium sulfate) is precipitated, especially in the single-phase process, and filtration is necessary.

A process designed to purify product of two-phase decomposition has been described by Distillers Company, Ltd.[22] First step in this method is distillative removal of acetone.

The bottoms of the acetone still are extracted with water at 158-194 F (weight ratio of water-to-crude product is approximately 6.0). This will remove most of the phenol and about one-quarter of the acetophenone from the reaction product. Cumene in the raffinate is freed of residual acetophenone by distillation and of alpha-methyl styrene by mild hydrogenation. It is then sufficiently pure to permit its return as feed to the autoxidation stage.

Aqueous extract is contacted with butyl acetate. This will remove 99 percent of the contained phenol, while acetophenone will remain in water solution. Some butyl acetate is recovered by distillation from the aqueous phase, in which it is dissolved in 0.5 percent concentration.

Phenol content of the butyl-acetate layer is of the order of 40 percent. The solvent is removed in a distillation step, leaving phenol with a residual acetophenone content of approximately 1.5 percent. By a final fractionation, phenol is rendered in commercially pure form, substantially free of acetophenone. Recovery is approximately 95 percent of the phenol leaving the decomposition stage.

For product recovery from acetone-homogenized decomposition, multi-stage distillation is practiced. In the first stage, acetone is taken overhead. Cumene and methyl styrene are removed in a second tower. Here, the use of steam distillation from alkaline solution offers advantages.

Bottoms leaving the secondary column are fractionated and the phenol, taken overhead, is crystallized to yield specification-grade product. Bottoms from the phenol column are principally acetophenone which can be recovered and upgraded to market specifications.

Adams[23] points out that in processes of this type, salt (which is dissolved in the organic layer during the neutralization step) will crystallize in the distillation equipment and transfer lines, causing severe operating difficulties.

This problem can be side-stepped by mixing the decomposition product with an equal volume of water before neutralization. The neutral mixture is settled. The aqueous layer is distilled to separate an overhead fraction consisting mainly of water plus some phenol and acetone. This fraction is recycled to the washing step.

The organic phase is fractionated for recovery of acetone and phenol, in accordance with the flow scheme shown.

Conclusion

The above discussion shows that the cumene hydroperoxide process is capable of yielding not only phenol and acetone but also minor amounts of acetophenone and alpha-methyl styrene. Each of these by-products is recovered by at least one commercial operator of the process in the United States.

Overall yield of phenol is reported to be between 85 and 90 percent based on cumene. Acetone yield is approximately the same.

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REFINERY CONSTRUCTION MANUAL

PART 5: PROCESS ENGINEERING AND DESIGN

. . . Process Design and Specifications
. . . How it Starts
. . . What it Does

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WHEN THE DECISION TO BUILD the refinery is firm and appropriations made, the engineering department issues a memo that establishes the broad outlines of the design.

This process information memorandum states unit types, capacities and product yields and qualities. The memo is based upon the chosen location and docking and transport facilities available, and shows the type of refinery steam and power plant, tankage needs, etc. On the basis of this memo, the process and mechanical design can start.

Getting Process Data

If there is a lack of specific data for detailed process design, laboratory evaluations are needed. The nature and extent of the laboratory work depends on the products and qualities desired.

For example, assume product requirements are gasoline, lube oils, diesel fuel, domestic heating oil, kerosine, and asphalt—perhaps using paraffinic-naphthenic crude oil combinations to meet all requirements. Studies would proceed according to the refinery flow chart available by this time—a simplified example being shown in Fig. 1. Yields, not shown here, are frequently included in this type of diagram.

Lube oil production would be tested, simulating refinery operations . . . vacuum distillation, propane deasphalting, phenol or furfural extraction, etc. . . . to establish yield-treat-quality curves for given conditions, and to get desired quality economically.

Kerosine and light fuel oil studies will include a number of possible treating processes to meet odor, sulfur, and burning specifications. Flash point specifications might in turn affect the operation of the crude still—demanding a close cut to exclude light ends.

For gasoline, it's easy to determine if catalytic cracking and reforming are needed to meet today's high octane levels. Catalytic cracking also enters, of course, into the overall yield structure desired. Desirability of alkylation, polymerization and hydrogen desulfurization will however, require further study. These matters usually will have been studied and decided upon in the planning stage, with detailed process engineering and product treating requirements studied at this point.

Similarly, the other desired products are made and evaluated on a laboratory scale to furnish specific data required by the process design engineers.

Process Design Work

After the basic type and duty of each piece of process equipment is known, process design work proper can start. To illustrate how this design work proceeds, the first stage of a two-stage pipe still, shown in Fig. 2, has been selected.

The first step is to prepare a table of products showing flow rates and physical characteristics for each stream and each operating alternative. The limiting operations cases . . . such as kerosine or heavy solvent naphtha production . . . are selected to give maximum flexibility in overhead side-stream equipment, under all anticipated services.

Data used in the table of products are based on a lab distillation of the crude and reference tables of physical properties.

The second step is to prepare a heat and material balance sheet and a tower loading table based on the flow diagram and the table of products.

Table 1 shows a typical balance sheet for the case where kerosine is made; Table 2 shows tower loading for kerosine production, and Table 3 shows product viscosities for both operating conditions. From these data, tower design is started and pumps and other equipment are specified.

The third step is to determine sizes and arrangements of the entire pipe still installation so that an economical heat exchange scheme may be applied. Optimum arrangement of heat exchangers, their heat transfer coefficients, pressure drops, effective mean temperature differences, and surface areas are now calculated.

Pumps, safety valves, product drums and exchangers are specified in detail. The furnace is specified as to number of tubes and sizes, firebox volume, tube arrangements, draft conditions, stack size and burner requirements. These are given as a master specification to the draftsmen and the requisitioners.

Heat transfer rates for exchangers and furnace can be calculated accurately for individual cases, but most often the design engineer can refer to past experience and avoid much of the time consuming work. There are books of standards developed by each group (and checking each other fairly well among various large companies) which are used to guide the design work in safe channels and eliminate many of the calculations needed for any new job.

Instrumentation is Important

Refinery instrumentation has become a most important item. Today's integrated processes operate with such small "hold-up" capacity that deviations of very short duration can have serious effects on product quality and operating economics.

Money spent for instruments is very small compared to the value of the service performed. It amounts to only one to two percent of the total cost of a new refinery. A large pipe still installation costing $2.5-million would have only about $75,000 worth of instrumentation, or three percent. This covers cost of the instruments themselves and the instrument panel in the control room, as well as lead-in lines and the compressor for instrument air.

Control instruments alone cost an average of $700 or better apiece. There may be 80 of them for a large cat

cracker, assembled on a central control panel costing around $20,000.

Control instruments for process units are in general about 50 percent flow controllers, 20 percent each of level and temperature controllers, and 10 percent of pressure controllers.

Pump Distribution

Modern refinery designs call for relatively few pumps, sometimes one spare being used for two or three similar services. There is also a trend to using the same spare pump for more than one category of potential service.

Typical pump distributions for a new and an older re-

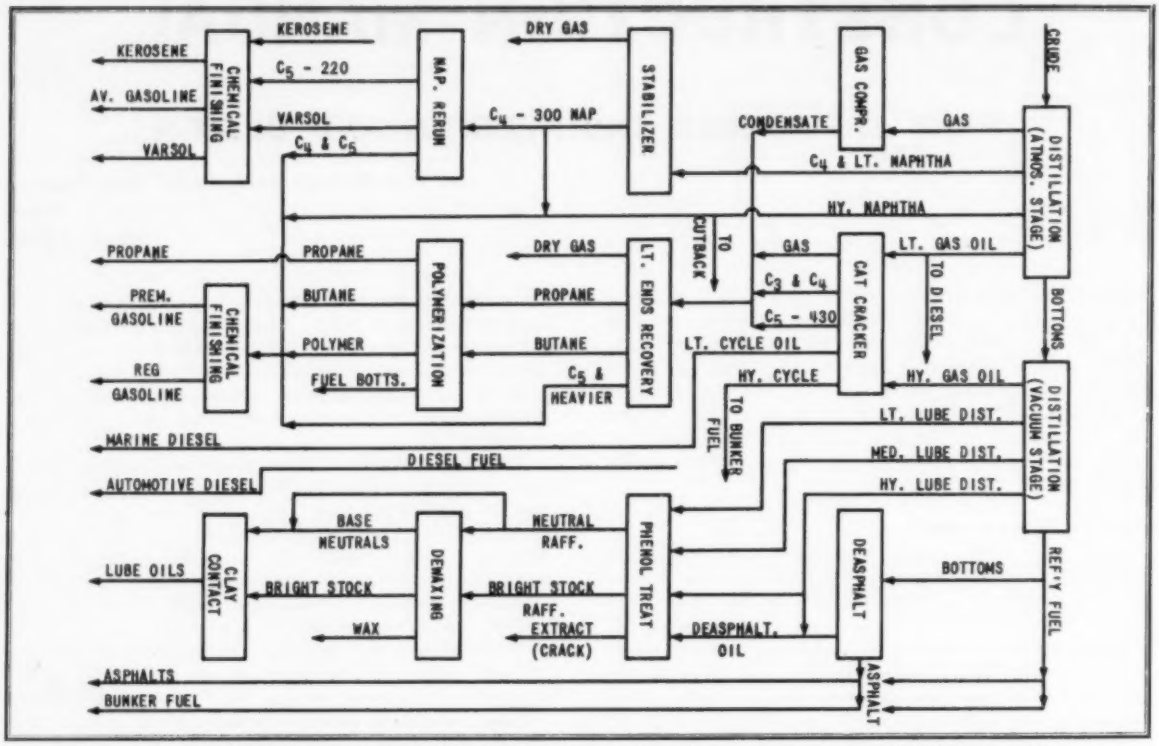
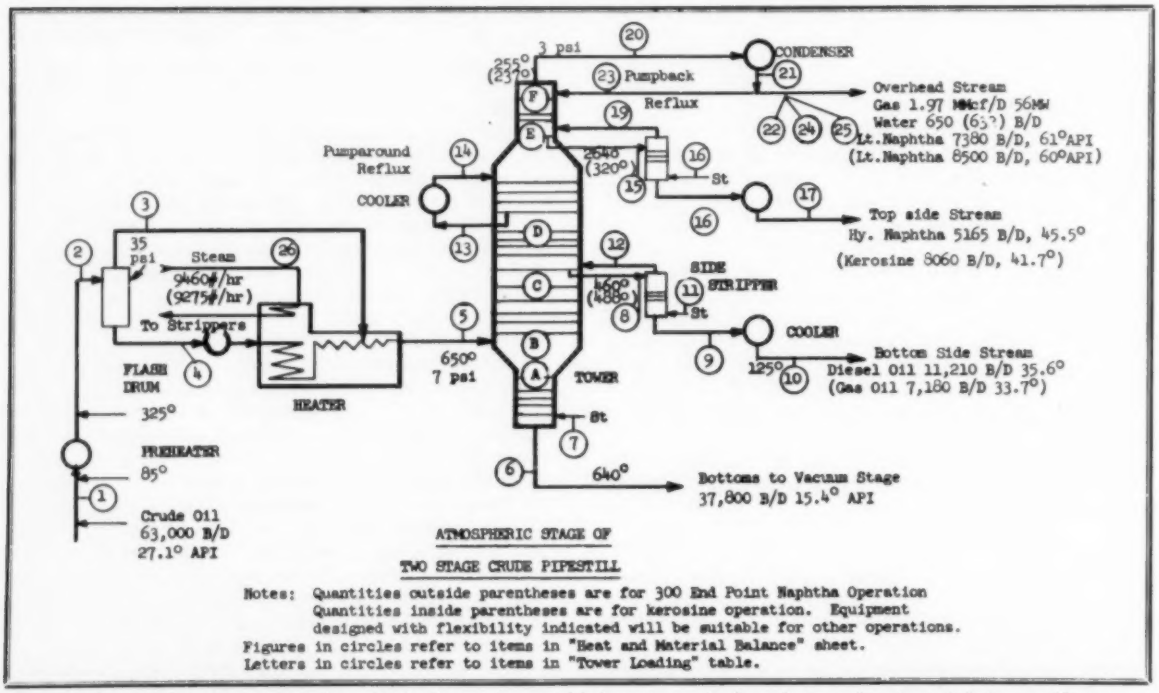


FIG. 1. **Simplified Refinery yield chart.** Only the flow pattern is shown here . . . rates are commonly included, too. Catalytic reforming of heavy naphtha and alkylation of butylenes with isobutane are two fairly common processes not shown here.



Notes: Quantities outside parentheses are for 300 End Point Naphtha Operation
Quantities inside parentheses are for kerosine operation. Equipment designed with flexibility indicated will be suitable for other operations.
Figures in circles refer to items in "Heat and Material Balance" sheet.
Letters in circles refer to items in "Tower Loading" table.

FIG. 2. **Process flow plan,** issued along with the heat and material balance, tower loading charts, and equipment design specifications.

finery differ greatly. Older refineries used a large number of reciprocating or simplex steam piston or plunger pumps. The modern refinery uses mostly centrifugal pumps, employing positive displacement pumps for very viscous liquids, emergency pumpouts, and minor services such as sealing liquid, proportioning, etc.

As to total pumps, a 1932-vintage 25,000 bbl per day refinery has a total of 332 pumps, while a similar-capacity current-design refinery has only 134.

Process Design Specifications

Every item of process equipment in the refinery must be covered by process design specifications showing pumps and instruments, piping for normal operation and startup or shutdown, bypasses, flow lines, etc. The more clearly piping is shown, the more easily it can be made into working drawings by the draftsmen.

It requires about 1000 hours to prepare process specification for a complete pipe still, in addition to any lab work.

TABLE 1. Typical Heat and Material Balance for Atmospheric Stage of Crude Pipe Still — Kerosine Operation. (See Fig. 2 for Location of Points and Flow Diagram of Still)

Point	Temperature	Pressure	Liquid quantity		Vapor quantity		Heat content above 100 F.
	F	psig	lb/hr	lb/gal	lb/hr	M. W.	MMBtu/hr, liq.
1	85	0.0	819,400	7.43	—	—	—4.8
2	325	—	819,400	7.43	—	—	95.0
3	310	35	—	—	27,000	45	—
4	310	35	796,000	7.53	—	—	88.1
5	650	7	530,500	8.02	288,900	138	294.4
6	640	7.5	530,500	8.02	—	—	164.2
7	500	10	—	—	6,600	18	8.0
8	488	6.3	119,460	7.04	—	—	—
9	445	6.8	89,460	7.13	—	—	17.4
10	125	—	89,460	7.13	—	—	1.1
11	500	10	—	—	1,255	18	1.5
12	475	6.3	—	—	31,255	123	—
13	(*)	5.1	—	6.85	—	—	(*)
14	(*)	4.5	—	6.85	—	—	(*)
15	320	4.5	125,600	6.58	—	—	—
16	275	5	95,800	6.80	—	—	9.3
17	100	—	95,800	6.80	—	—	0.0
18	500	10	—	—	1,410	18	1.7
19	305	4.5	—	—	31,210	80	—
20	255	3	—	—	218,815	82	55.3
21	110	1	206,675	6.24	12,140	56	3.0
22	110	—	91,500	6.15	—	—	0.46
23	110	3	105,900	6.15	—	—	0.54
24	110	1	—	—	12,140	56	1.91
25	110	1	9,215	8.33	—	—	0.09
26	250	15	—	—	9,275	18	10.1

(*) Quantity of pumparound reflux and temperatures of reflux to and from tower to be determined as part of equipment design.

Heat removal by pumparound reflux = 59.5 MMBtu/hr.
Vapor temperature into pumparound section = 437 F.

TABLE 2. Typical Tower Loading Chart for Atmospheric Stage of Crude Pipe Still — Kerosine Operation. (See Fig. 2 for Location of Zones and Flow Diagram of Still)

Zone Number	A	B	C	D	E	F
Location of Zone by Plates	Above #4	Below #5	Below #9	Below #15	Below #16	Below #22
Vapor Leaving Zone, Incl. Steam						
Temperature, F	650	650	540	450	360	265
Pressure, psig	7.0	7.0	6.5	5.1	4.5	3.0
MMcf/D	4.8	23.9	32.5	42.6	19.5	31.1
lb/hr	46,400	335,000	545,540	643,335	207,335	281,915
Molecular weight	88	128	153	137.5	97.2	82.6
Liquid Entering Zone						
Temperature, F	650	640	515	437	Total SS	255
Bbl per day at 60 F	40,950	3,150	20,050	36,400	drawoff	16,070
lb/hr	570,300	39,800	250,000	436,000	to	169,000
lb/gal	7.96	7.21	7.13	6.85	product	6.01

Note: Compressibility factor of all vapor streams essentially 1.0 at operating conditions.

TABLE 3. Typical Viscosity Chart for Feed and Products for Atmospheric Stage.

300 F Light Naphtha Operation	°API	Viscosity, Centistokes @ 100 F	210 F
Crude	27.1	21.8	5.0
Light naphtha	61.0	0.7	0.4
Heavy naphtha	45.5	1.1	0.6
Diesel oil	25.6	2.8	1.1
Bottoms	15.4	1700	60
Kerosine Operation			
Crude	27.1	21.8	5.0
Light naphtha	60.0	0.7	0.4
Heavy naphtha	41.7	1.5	0.7
Diesel oil	33.7	3.6	1.3
Bottoms	15.4	1700	60

Included in the specifications are calculated utility requirements—steam, electric power, etc.

Process designers are responsible for starting up newly built process units, and as a matter of routine they also prepare complete and detailed operating manuals for the operators.

Usually about 12 process specifications are needed for a complete refinery — two to five for a cat cracker and only one for a simple pipe still.

Time occupied by the process design group for the project is about eight months on a complete refinery, about two to four months on a cat cracker, and about one to two months on a pipe still.

Next Month, *The Refinery Construction Manual's sixth chapter will discuss "Mechanical Engineering and Design."*

CALCULATE PIPE STRESSES EFFICIENTLY

Part 3. Forces in Single Plane Systems, Locating Centroids and Application

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Self-Checking Way of Locating Centroids in Table 1[1]

In piping stress calculations, the tabulation of correct x, y, and z coordinates for each branch and each elbow of the system is of the utmost importance. The accuracy of the coordinates can be assured as soon as their numerical values are tabulated by the following "self-checking way." For instance, for the system in Fig. 3,[2] starting from end "a," the location of the centroid of each branch or elbow is calculated as below:

x	y	z
27.70 ab	3.20 ab	0 ab, bc, cd, de, ef
.54	3.20	− .54 fg
27.16 bc	.96	− .54
.96	7.36 bc	− .96
26.20	.54	− 8.50
12.35	7.90 cd (check)	− 10.00 gh
13.85 cd	.54	− 8.50
12.35	7.36 de	− .96
1.50	.96	− 19.46 hk
.96	6.40	− .54
.54 de	2.45	− 20.00 (check)
.54	3.95 ef	
0 ef, fg, gh (check)	2.45	
− .54	1.50 (check)	
− .54 hk (check)	.96	
	.54 fg	
	.54	
	0 gh, hk (check)	

This self-checking way of locating centroids can also be applied in Table 2 for the tabulation of x, y, and z coordinates for points "a" to "l" inclusive.

Advantages of this procedure. In addition to saving time and labor, without sacrificing accuracy, there are the following advantages for the procedure presented here:

1. The proportion of simplification increases with the number of branches and elbows. Increase in branches only increases the numerical values under headings "branches" and "elbows" and does not affect the remaining portion of Table 1. Thus, if the number of branches and elbows is increased from 7 to 14, the only change in Table 1 is the tabulation of 7 additional rows of numerical values.
2. It is not necessary to locate in three perpendicular planes (in addition to an isometric view): (a) The true centroidal axes of the piping system, (b) the coordinates with respect to these axes of individual centroids of different piping branches and elbows (for calculation of line inertia values), and (c) the coordinates of ends and joints between the piping branches (for calculation of moments and torques). The analyst requires only a simple isometric view, where such locations are unnecessary.
3. It is not necessary to carry out computations for line inertias in three different tables for three perpendicular planes. Only one table, i.e., Table 1, suffices.
4. The procedure in Table 2 reduces the work of determining signs for moments and torques at all points in a system to that at only one point.

All of the above advantages reduce chances for errors.

Example Problem

In this example, a single-plane system subjected to expansions including that perpendicular to its own plane is analyzed. This system, shown in Fig. 4, is the same as that portion in XY plane of the system in Fig. 3, except (1) "fg" is changed to a straight branch 18 in. long, and (2) the end "g" is connected to a large-diameter header at the same temperature and anchored at a distance 20 ft away from "g."[3]

For expansion, the system in Fig. 4 is fixed at the anchors, but for flexibility, it is assumed to be fixed at points "a" and "g," due to the great stiffness of the header.

[3] If this connection is a welding tee, the stress intensification factor at the connection is: $\frac{0.9}{h^{5/3}}$ where $h = 4.4\ \frac{t}{r}$.

Equating $I_{xz} = I_{yz} = 0$ in Equations 4, 5, and 6 we have:

$$X - Y\left(\frac{I_{xy}}{I_x}\right) = \frac{\Delta_x E_c I}{1728\, I_x} \quad . \quad . \quad . \quad (24)$$

$$-X + Y\left(\frac{I_y}{I_{xy}}\right) = \frac{\Delta_y E_c I}{1728\, I_{xy}} \quad . \quad . \quad . \quad (25)$$

$$ZI_z = \frac{\Delta_z E_c I}{1728} \quad . \quad . \quad . \quad . \quad . \quad (26)$$

It is seen from Equations 24, 25, and 26 that the force act-

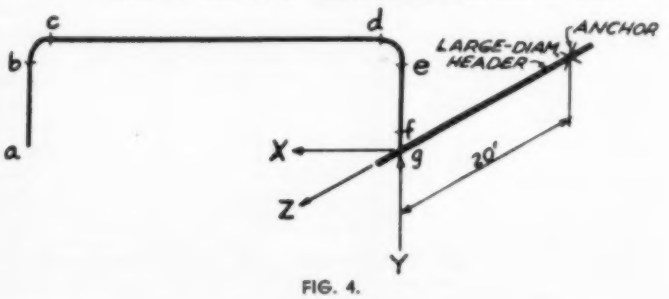

FIG. 4.

[1] See *The Refining Engineer*, May 1958, page C-46.
[2] See *The Refining Engineer*, June 1958, page C-26.

		DESIG-NATION	X	Y	L^3	L	Lx^2	Ly^2	Lxy
Y BRANCHES		ab	27.7	3.2	262.1	6.4	4,900	65.5	566
		ef	0	3.95	117.6	4.9	0	76.5	0
		fg	0	0.75	3.4	1.5	0	.8	0
	(1)	SUM			I_z= 383.1		4,900	142.8	566
	(2)	(1)×0.3					1,470		
X BRANCH		cd	13.85	7.9	15,069	24.7	4,740	1,543	2,700
	(3)	SUM			I_x= 15,069		4,740	1,543	2,700
	(4)	(3)×0.3						463	
XY ELBOWS		bc	27.16	7.36			737	54.2	200
		de	0.54	7.36			0.3	54.2	4
	(5)	SUM					737.3	108.4	204
	(6)	(5)×β	β = 22.6				16,680	2,450	4,610
	(7)	(5)×α	α = 24.9				18,370	2,700	5,080
	(8)	(1)+(3)+(7)					28,010	4,386	8,340

I'_x 6,836 I'_y 44,690 XY (6)+(8) I'_y 44,690 I'_x 6,836 $\sqrt{2956 I_{xy}}$

$I_{z/2}$ 32 $I_{3/2}$ 1,257 XZ (2)+(5) I'_z 29,480

I_x 6,868 I_y 45,947 YZ (4)+(5) I''_z 4,849

I'_z 29,480 I''_z 4,849 $I_{3/2}$ 32 $I_{3/2}$ 1,257 I_z 35,618

COEFFICIENTS

$-\frac{I_{xy}}{I_x} = -\frac{12,956}{6,868} = -1.89$ $\frac{\Delta_x E_c I}{I_x 1728} = \frac{4.1(27.4)10^6(140.9)}{6868\,(1728)} = 1,330$

$\frac{I_y}{I_{xy}} = \frac{45,947}{12,956} = 3.54$ $\frac{\Delta_y E_c I}{I_{xy} 1728} = 0$

$\frac{\Delta_z E_c I}{1728} = \frac{2.62(27.4)10^6(140.9)}{1728} \times 10^6 = 5.84$

TABLE 4.

ing in the direction of Z-axis is independent of expansions in the plane of the system, and the forces acting in the same plane are also independent of expansion along Z-axis. To obtain line inertias in the above equations, we use Table 3, which is a modified version of Table 1. Owing to the similarity between systems in Fig. 3 and 4, the calculated numerical values in Table 1 for members "ab" to "ef" inclusive are retabulated in Table 3.

Substituting the coefficients from Table 3 in Equations 24, 25, and 26, we have:

$$X + .056\,Y = 36,850$$
$$-X - 1467\,Y = 0$$
$$13,503\,Z = 5,840,000$$
$$Z = 432 \text{ lb}$$
$$Y = -25 \text{ lb}$$
$$X = 36,850 \text{ lb}$$

Thus, by reducing the flexibility of a three-dimensional system to that of a single-plane system, while maintaining the same expansion in three directions, the force X becomes prohibitively large. The negative sign of Y force indicates that its direction is opposite to that assumed in Fig. 4. The above values for X, Y, and Z are force ranges, from which the moment ranges and the hot and cold forces, moments, and torques can be calculated in a similar manner to Example 1.

If end "g" of the system in Fig. 4 is fixed with respect to translatory motions, but is free to rotate, then it is like a hinged end. In this case, the X, Y, and Z axes shown in Fig. 4 are also the final axes, thus eliminating the necessity of calculating $\bar{x}$, $\bar{y}$, and $\bar{z}$. Table 3 is then reduced to Table 4, which indicates greater line inertia values or greater flexibility, resulting in smaller expansion forces. (X = 2840 lb, Y = 800 lb, Z = 164 lb.)

Similar changes can be made in Table 1 to adapt it to a three-dimensional system with one end hinged. This is accomplished by eliminating Lx, Ly, and Lz columns and reducing XY, XZ, and YZ tables to nine line inertia values, i.e., I'_x, I'_y, I'_z, I''_x, I''_y, I''_z, I_{xy}, I_{xz}, I_{yz}.

Reductions and Modifications of Table 1 for Special Cases

Fig. 4 is a special case of a single-plane system. Eliminating rows (2), (4), and (6) and those portions of Table 3 under headings "XZ" and "YZ," and changing row (7) to (7) = (5) × KL_a, we obtain a table for calculating I_x, I_y, and I_{xy} for any single-plane system not subjected to expansion perpendicular to its own plane. Substituting the above line inertias in Equations 24 and 25, we can solve for the forces X and Y, which equal the X and Y forces obtained for the system in Fig. 4. Thus, Table 1, when reduced to the form of Table 3, provides a tabulation procedure for the particular case in Example 2 or other similar cases. When reduced further, Table 3 provides a means of tabulation for any simple single-plane system.

Eliminating that portion of Table under headings "Elbows," Table 1 is transformed into a simpler form for an approximate solution for a system assumed to be square-cornered.

If the elbows of the system in Fig. 3 are changed to mitre bends, all the numerical values above row (14) of Table 1, calculated for Example 1, can be

		DESIG	x	y	L^3	L	Lx	Lx^2	Ly	Ly^2	Lxy	TABLE 1 ROW NO.
Y BRANCHES		ab	27.7	3.2	262.1	6.4	177	4900	20.5	65.5	566	
		ef	0	3.95	117.6	4.9	0	0	12.4	76.5	0	
		fg	0	.75	3.4	1.5	0	0	1.1	.8	0	
	(1)	SUM			I_z= 383.1		12.8	177	4900	41.0	142.8	566 (3)
	(2)	0.3×SUM					3.8	53.1	1470			(4)
X BRANCH		cd	13.85	7.9	15069		24.7	342	4740	195.2	1543	2700
	(3)	SUM			I_x= 15069		24.7	342	4740	195.2	1543	2700 (5)
	(4)	0.3×SUM					7.4			58.6	463	(6)
XY ELBOWS		bc						27.16	737	7.36	54.2	200
		de						.54	.3	7.36	54.2	4
	(5)	SUM						27.70	737.3	14.72	108.4	204 (7)
	(6)	(5)×β	β = 22.6					45.2	616	1666	333	2450 4610 (8)
	(7)	(5)×α	α = 24.9					49.8	690	18,370	366.5	2700 5080 (9a)
	(8)	(1)+(3)+(7)						87.3	1209	28010	602.7	4386 8346 (9b)
								132.5	1834	44,690	935.7	6836 12,956 (10)
								$\bar{x}$ = 13.85		$\bar{y}$ = 7.07		(11)
								$\bar{x}\sum Lx$ = 25,400		$\bar{y}\sum Ly$ = 6620		12,970 $-\bar{y}\sum Lx$ (18)
								I'_x = 19,290		I_{xy} = 216		−14 $-I_{xy}$ (19)
								94.1	1262.1	29480		(20)
								$\bar{x}$ = 13.85				(21)
								$\bar{x}\sum Lx$ = 17,600				(22)
								I'_z = 11,980				(23)
								94.7		661.3	4849	(24)
										$\bar{y}$ = 6.98		(25)
										$\bar{y}\sum Ly$ = 4615		(26)
										I_z = 234		(27)

I'_x = 216; $I_{z/2}$ = 32; I_x = 248

I'_y = 19,290; $I_{3/2}$ = 1,257; I_y = 20,547

I'_z = 11,980; I''_z = 234; $I_{z/2}$ = 32; $I_{3/2}$ = 1,257; I_z = 13,503

COEFFICIENTS

$-\frac{I_{xy}}{I_x} = \frac{-14}{248} = .056$ $\frac{\Delta_x E_c I}{I_x 1728} = \frac{4.1(27.4)10^6(140.5)}{248\,(1728)} = 36,850$

$\frac{I_y}{I_{xy}} = \frac{20,547}{-14} = -1467$ $\frac{\Delta_y E_c I}{I_{xy} 1728} = 0$

$\frac{\Delta_z E_c I}{1728} = \frac{2.62(27.4)10^6(140.5)}{1728} = 5.84(10^6)$

TABLE 3.

	SUM ELBOWS		27.18	737.6	15.26	108.7	-20	378.3	204	10.5	-.3
(7)	Σ SUM	128.8	875	23,750	491	3,500	-644	12,180	6,570	338	-9.7
	(8)=(1)+(3)+(5)+(7)	184.8	1394	33390	726.1	5,185	-814	13,880	9,836	338	-9.7
	(9) Σ =(2)+(8)	186.9	1394	33390	726.1	5185			9,836		
Y	(10)=(9)+ΣL		X̄ 7.46		Ȳ 3.88						
X	(11)=(10)×Σ		ΣXL 10,400		ΣYL 2,820				ΣZL 5,410		
	(12)=(9)−(11)		I'_y 22,990		I'_x 2,365				I_{xy} 5,426		
	(13) Σ =(4)+(8)	185.2	1,447.1	34,860			-814	13,880		338	
	(14)=(13)+ΣL		X̄ 7.82				Z̄ -4.39				
Z	(15)=(14)×Σ		ΣXL 11,300				ΣZL 3,575		ΣZL −6,360		
	(16)=(13)−(15)		I'_z 23,560				I'_x 10,305		I_{xz} +6,698		
	(17) Σ =(6)+(8)	189.2			784.7	5,648	-814	13,880			-9.7
	(18)=(17)+ΣL				Ȳ 4.15		Z̄ -4.3				
Y	(19)=(18)×Σ				ΣYL 3260		ΣZL 3,500			ΣYL −3370	
	(20)=(17)−(19)				I'_z 2,388		I'_y 10,380			I_{yz} 3,360	

TABLE 5.

used with the insertion of new values for rows (8), (10), and (12). These new values are calculated, using a new β factor obtained as follows:

Applying Equations 12, 13, 14, 15, 16, 17, and 20 to the piping in Fig. 3, we have:

$$h = \frac{1 + \cot 22.5^\circ}{2}\left(\frac{0.180}{6.285}\right) = .0489$$

$$K = \frac{1.52\sqrt[3]{(.0489)^{1/2}}}{.0489} = 18.8$$

$$R = \frac{6.285(1 + \cot 22.5^\circ)}{2} = 0.9 \text{ ft}$$

$$L_n = \frac{\pi(0.9)}{2} = 1.41 \text{ ft}$$

$$\alpha = \left(\frac{18.8 + 1}{2}\right) 1.41 = 13.95 \text{ ft}$$

$$\beta = \left(\frac{18.8 - 1}{2}\right) 1.41 = 12.55 \text{ ft}$$

$$i = \frac{0.9}{(.0489)^{2/3}} = 6.75$$

The above interchangeable use of numerical data in Table 1 is based on the assumption that the location of centroid of each mitre bend is close to that of its corresponding elbow.

When the piping system contains branches and elbows with different cross-sectional moments of inertia I_1, I_2, I_3, ... I_n, of which the number of sections with I_n is predominant, then we apply ratios I_n/I_1, I_n/I_2, ... I_n/I_{n-1} to the lengths and centroidal line inertias of members with cross-sectional moments of inertia other than I_n, and substitute I_n for I in Table 1. For instance, if branch "ab" of the system in Fig. 3 is changed to 10-in. diameter, Schedule 10S ($I = 76.9$ in.^{4}). Since, in this case, the number of 12-in. pipe is predominant, we apply the ratio $\frac{140.5}{76.9} = 1.83$ and obtain the following values:

$$L_{ab} = 1.83 \times 6.4 = 11.7 \text{ ft}$$

$$I_2 = 1.83 \times 262.1 + 117.6 = 597.6 \text{ ft}^3$$

Replacing values for branch "ab" in Table 1 of Example 1 with the above values, we obtain the tabular solution for this piping system.

Changes in the formulae and application of the flexibility factor K and stress intensification factor "i" are two of the most significant code changes published in the 1955 ASA Code for Pressure Piping. Such changes may well reoccur in future codes, but the tables presented in this paper are still applicable. For instance, if the flexibility factor for bending is changed from K to K_1, and that for torsion, from unity to K_2, then the new transverse and differential virtual lengths are

$$\alpha = \frac{K_1 + K_2}{2} L_n \qquad \beta = \frac{K_1 - K_2}{2} L_n$$

The above factors will be applied in Table 1 for calculations of line inertias.

Mean Virtual Length of Elbow

The mean virtual length of an elbow is the average value of the virtual length KL_n for in-plane bending and the two transverse virtual lengths α for bending in the other two planes. Hence, it is defined as:

$$\gamma = \frac{KL_n + 2\alpha}{3} = \frac{KL_n + 2\left(\frac{K+1}{2}\right)L_n}{3} = \frac{2K+1}{3} L_n \quad \ldots\ldots\ldots\ldots\ldots\ldots (27)$$

Applying this factor to Equation 7, we have, for I'_x, the following changes:

$$\left.\begin{array}{l} \alpha \sum_{i=\text{all elbows}} y_i^2 + \beta \sum_{i=\text{elbows} \parallel XY} y_i^2 \longrightarrow \gamma \sum_{i=\text{all elbows}} y_i^2 \\ \alpha \sum_{i=\text{all elbows}} y_i + \beta \sum_{i=\text{elbows} \parallel XY} y_i \longrightarrow \gamma \sum_{i=\text{all elbows}} y_i \end{array}\right\} . \quad (28)$$

Similar changes occur for line inertias in other planes. The resulting simplification is the elimination of rows (7) to (12) inclusive in Table 1. Also, the calculations for rows (9), (13), and (17) become additions of two rows each, instead of three rows. For the system in Fig. 3, $\gamma = \frac{2(20.1) + 1}{3} \times 2.35 = 32.2$. The numerical calculations are shown in Table 5, which is the lower portion of Table 1. The data in the upper portion of the original Table 1, i.e., the numerical values under "branches" and those for individual elbows, are still applicable in this case.

The greatest force obtained from Table 5 is X = 1003 lb or 9 percent larger (on the conservative side) than that of Table 1. The maximum bending moment calculated from X, Y, and Z forces is 18 percent greater than that of Table 1. Thus, the use of mean virtual length provides an approximate, simplified solution. It should be remembered in this connection that piping flexibility calculations, however precisely made from a mathematical standpoint, will always remain approximate due to the multitude of assumptions involved. The formula for γ, i.e., Equation 27, should be further refined to include a factor, which varies as a function of the distribution of elbows among the three planes. Such a factor would improve the accuracy and cause the numerical results to approach those in Table 1. ★ ★ ★

This concludes the three-part series *Calculate Pipe Stresses Efficiently*. **Part 1, in the May issue, discussed calculating forces for a three-dimensional system and Part 2, published in June, showed how to determine moments, torques, and defined stress ranges and design limits.**

MODERN GASOLINE PLANTS

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Dave Vondy
Constructive Engineering Company
New Orleans, Louisiana

Part 6: Dehydration and Inhibiting Hydrate Formation

IT HAS BECOME UNIVERSAL practice to reduce water content of natural gas to prevent hydrate formation problems in transmission lines. Sales contracts generally limit water content to 7 lb per MMscf, except in northern areas where lower temperatures require a lower water content. Gas dewpoint depression necessary to obtain a 7 lb per MMscf water content is shown in Fig. 40, as a function of pressure and gas temperature.

In addition to meeting gas product specifications, hydrate formation must be prevented prior to low temperature processing. This can be accomplished either by reducing the water content or by inhibiting hydrate formation. Re-dehydration of gas would be required in situations where dry gas is contacted with lean oil that has been steam stripped in the rich oil section, the dry gas becoming re-saturated from moisture in the lean oil.

Location, Costs of Dehydration Facilities

Dehydration plants are usually located either in the gas producing area or at a processing plant, to realize low operating cost and minimum trouble by providing already available operator attention. Remote facilities frequently are included in the gathering system to eliminate local transmission problems.

Relative lifetime cost of dehydration, including initial installed cost plus discounted future operating costs, is shown for several methods in Fig. 41. These data should be approximately true for the general situation where each of these schemes would be applicable.

When there is adequate gas pressure to provide natural refrigeration, it is most economical, primarily because of low future costs. Otherwise, glycol absorption is generally the most economical scheme, with dry desiccant adsorption having a somewhat higher overall cost. It should be noted that dry desiccant adsorption is often justified over glycol absorption when recovery of distillate by the adsorbent is an important factor. Dehydration with a chemical that is replaced when it becomes water-saturated is usually uneconomical.

Determination of whether dehydration or inhibiting is more economical for a particular situation involves analysis of several factors. Included would be loss of chemical due to solubility in liquid product, operating conditions, relative operating problems and initial cost of each method.

Dry Desiccant Adsorption

A typical dry desiccant system is illustrated in Fig. 42. Two or more desiccant beds are used. Wet gas flows through one while the other is being regenerated with about 12 percent of the main (feed) gas. Temperature of the bed being regenerated will rise to about 350 F.

Usual cycle for a tower is eight hours drying, six hours heating to remove adsorbed water, and two hours cooling. Regeneration gas is cooled by the dried main gas stream or cooling water, to condense water. This gas is then returned to the incoming main stream for dehydration. Cooling the regenerated bed slowly, prior to charging of main gas, is desirable to avoid breaking the desiccant particles by rapid temperature change.

A number of desiccants are available, including activated alumina, fluorite, Mobilbeads and silica gel. Their capacity ranges from 3 to 10 lb of water per lb in normal service. Capacity declines with service due to poisoning, eventually requiring replacement. Capacity of many desiccants decreases rapidly with increase in temperature. Since gas processing capacity of a given unit depends on total amount of water to be removed, care must be exercised in selecting operating conditions: Decrease in pressure and increase in temperature appreciably increase product gas water content.

Relative water content of gas at saturation is plotted as

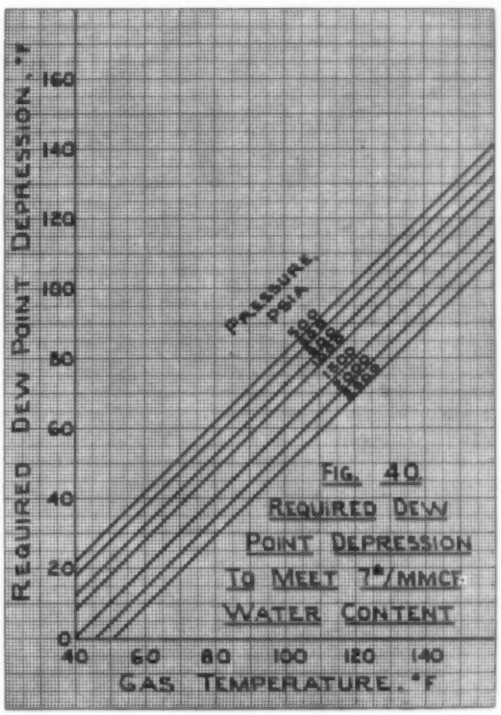


FIG. 40 REQUIRED DEW POINT DEPRESSION TO MEET 7#/MMCF WATER CONTENT

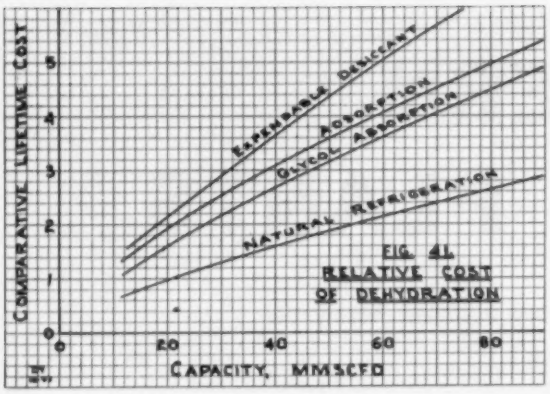


FIG. 41. RELATIVE COST OF DEHYDRATION

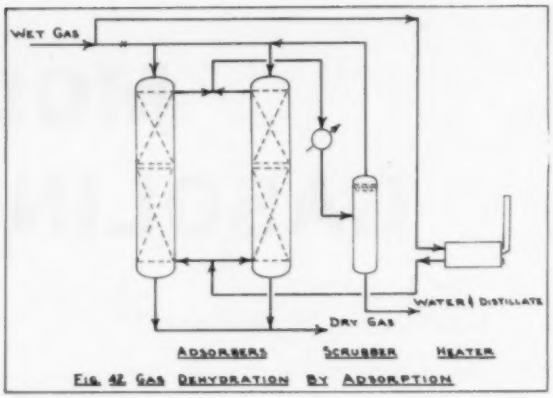


FIG. 42. GAS DEHYDRATION BY ADSORPTION

a function of pressure and temperature in Fig. 43. Data in this chart indicate that three times as much desiccant would be required at 120 F as at 80 F, and more if desiccant capacity were less at the elevated temperature. It may be practical to provide for future additional capacity by oversizing the desiccant vessels and employing a low-capacity desiccant at the outset, especially if long range requirements cannot be accurately predicted. When needed, it would then be possible to substitute higher-capacity desiccant to increase throughput, or amount of dehydration.

It is practical to cool inlet gas in some circumstances, thus reducing desiccant requirements. Higher gas temperatures occur most frequently when the dehydrator is downstream of compression facilities. It may also be practical to operate the beds on a shorter cycle during high temperature periods, as in the summer.

Vertical adsorbers, as shown in Fig. 42, are most often preferred. Main gas flow is downward to avoid desiccant loss, with regeneration gas flowed upward to provide counter-current regeneration. Although lower gas velocities are desirable for best results, main gas velocity of near 50 ft per sec is likely economical for the general situation. But, 20 ft per sec is preferred for transmission systems where pressure drop must be made up by compression. A gap in the desiccant bed, near the center of the tower, is desirable to effect re-distribution, thereby minimizing channeling.

Horizontal adsorber vessels, divided into compartments with gas distribution through headers, are more practical than vertical units in cases where main gas rate is considerably below capacity for long periods. Here's why. Regeneration heat load is to a large extent that necessary to bring the vessel and desiccant up to the required temperature. At main gas rates considerably below capacity, a relatively high regeneration gas rate is required. If one or more compartments of a bed can be taken out of service, more efficient operation will be realized at reduced rates. Attention to method of construction and materials selected will overcome the usual objection to elaborate internals in horizontal adsorption vessels.

Regeneration. It is sometimes practical to regenerate desiccant with heat from an available source such as steam (direct heating) or hot oil (indirect heating). A closed gas cycle has the advantage, however, of making a unit independent of other plant facilities and usually has a relatively low operating cost. In some instances gas at reduced pressure can be used for regeneration, for example when a small stream can be taken from an inner stage of a centrifugal compressor. In some plants, wet regeneration gas flows to the exiting main gas stream, but, the resulting high dewpoint may make the scheme impractical, particularly at relatively high regeneration gas rates as would be required at low main gas rates.

Automatic controls are usually justifiable, to reduce operating cost and to secure best operation. A number of plants are operating, however, with manual switching . . . especially when a full-time operating crew would have been available regardless. Recording of primary inlet temperatures is valuable for operations analysis and to facilitate troubleshooting.

Minimizing desiccant poisoning. Reduced desiccant capacity is frequently caused by heavy hydrocarbons in the gas that are not stripped out during the regeneration cycle. Root of the problem is often upstream of the plant, where absorption oil is carried over, or compressor lubricating oil gets into the gas stream in excessive quantities. It is not unusual for desiccant life to be reduced from the practical three-year period to less than a year.

Although some success has been attained for regenerating certain desiccants in place with light solvent or by controlled burning, removal of heavy ends from the gas is usually the most practical solution. First and most important step is effective mist extraction . . . the recent trend has been toward use of a wire mesh pad to remove entrained

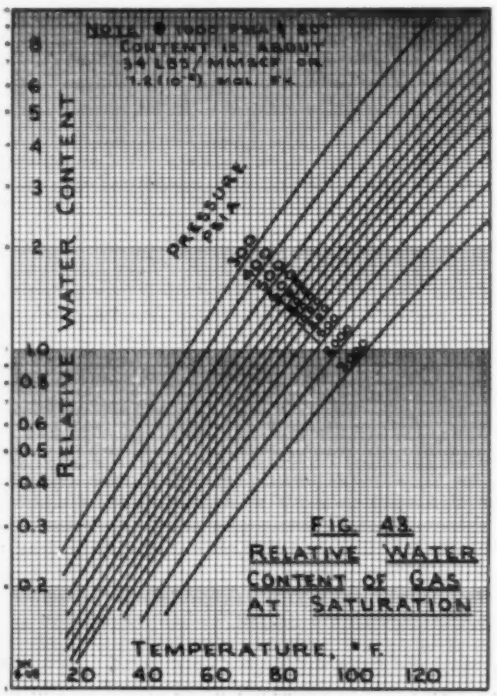
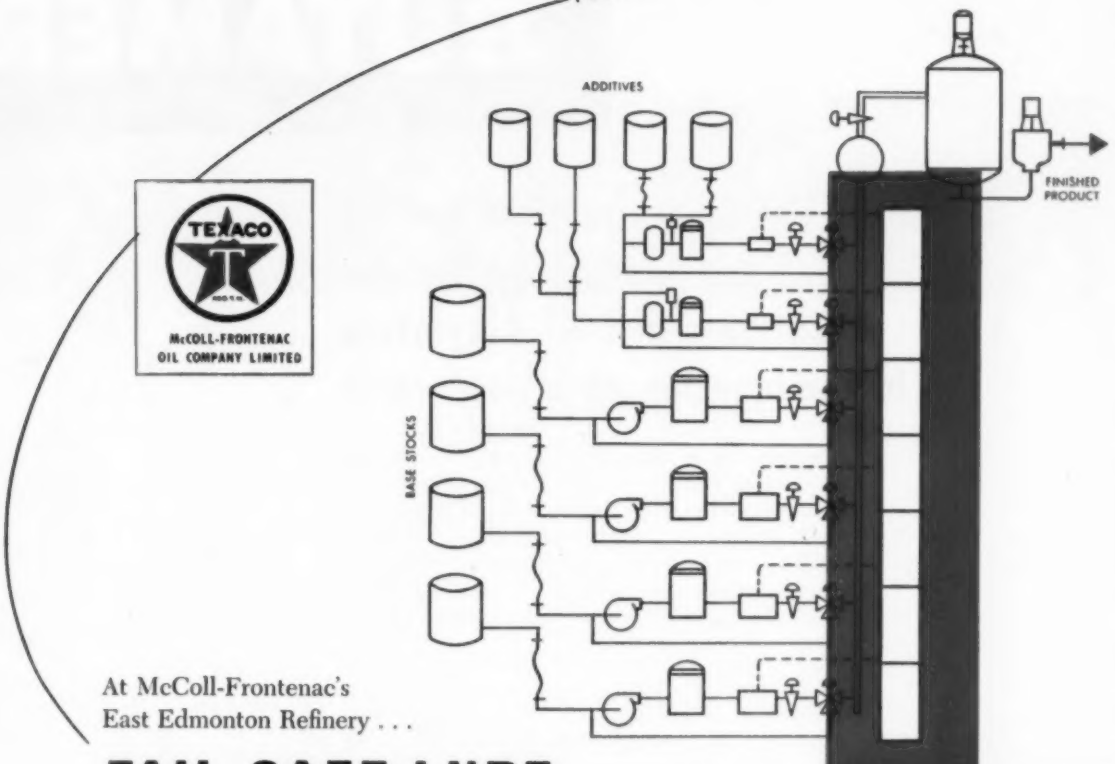


FIG. 43. RELATIVE WATER CONTENT OF GAS AT SATURATION

POSITIVE CONTROL OF MATERIALS IN MOTION



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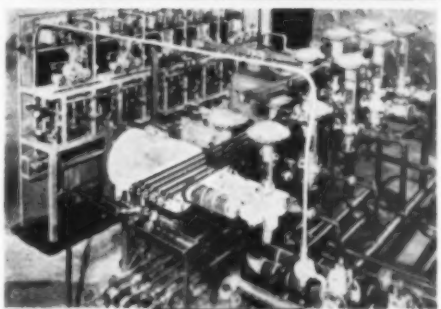

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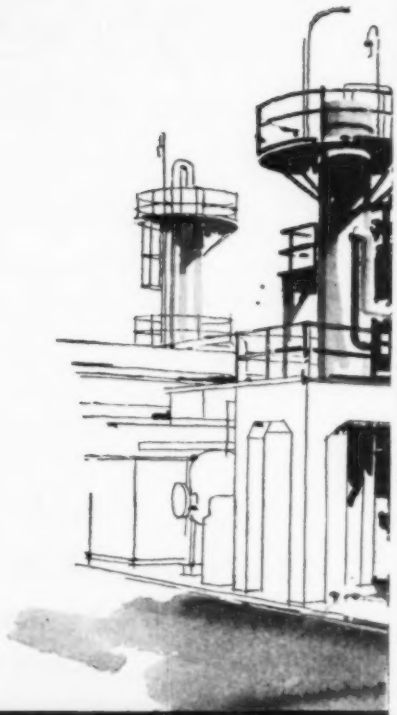

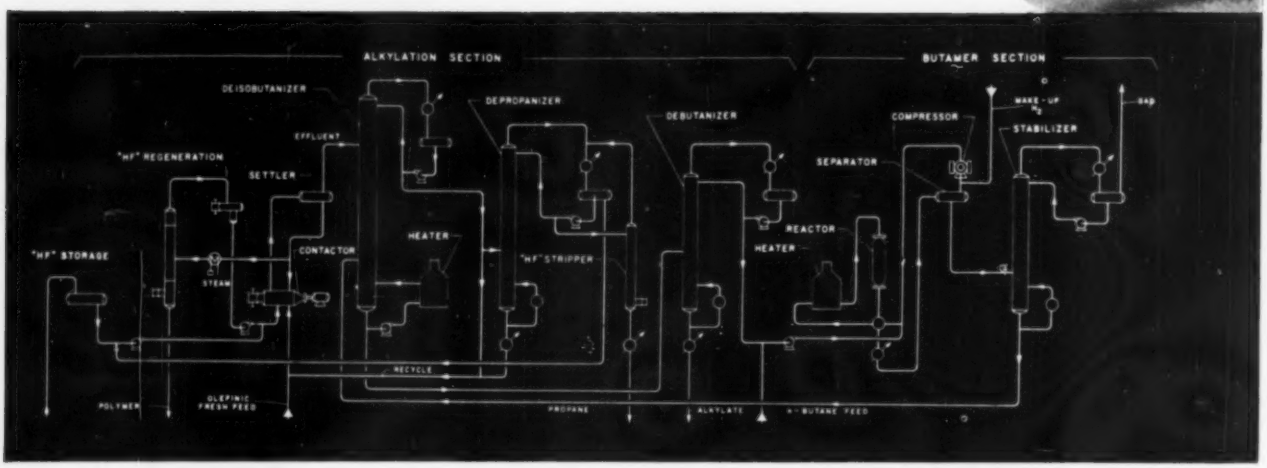

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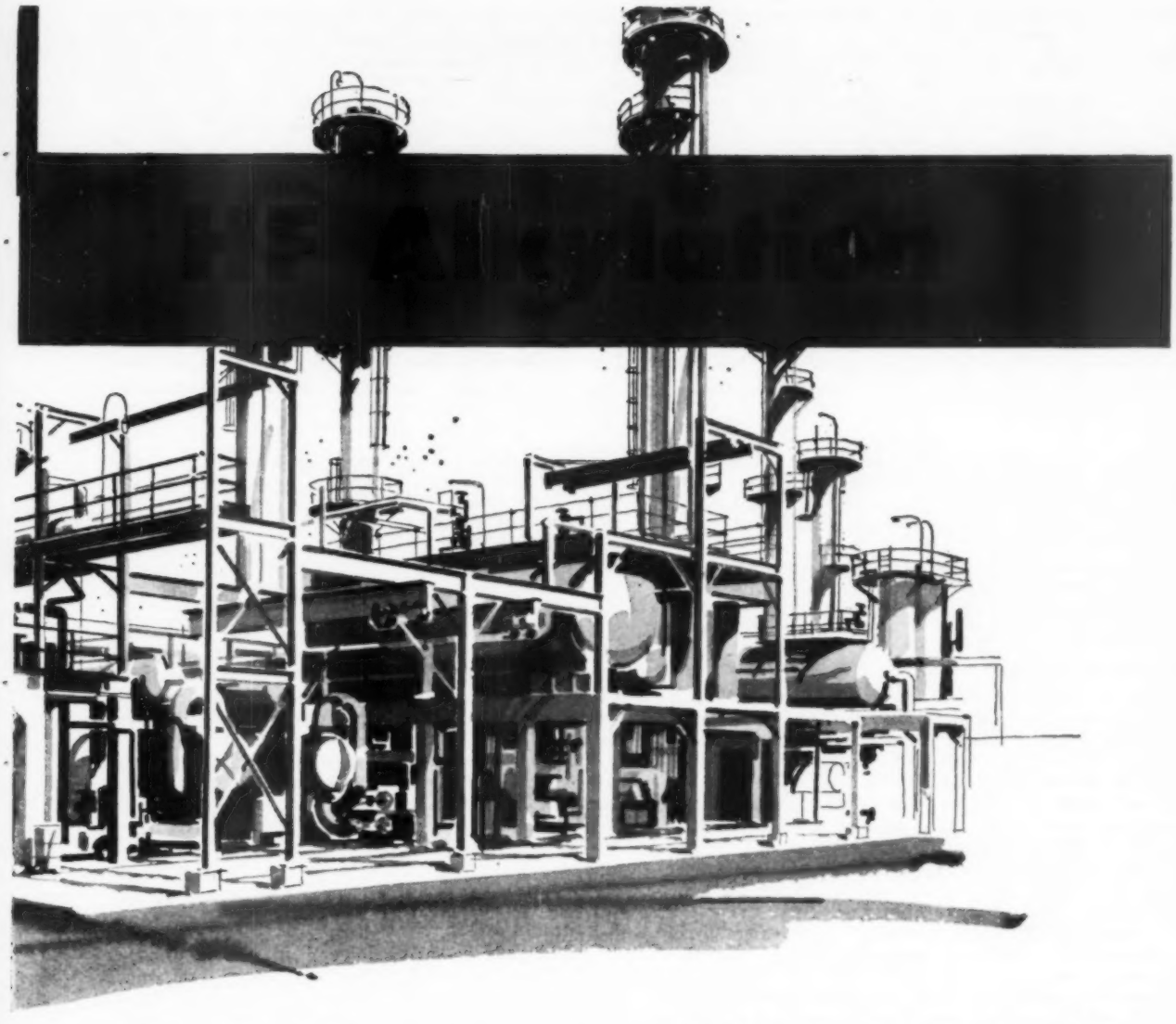

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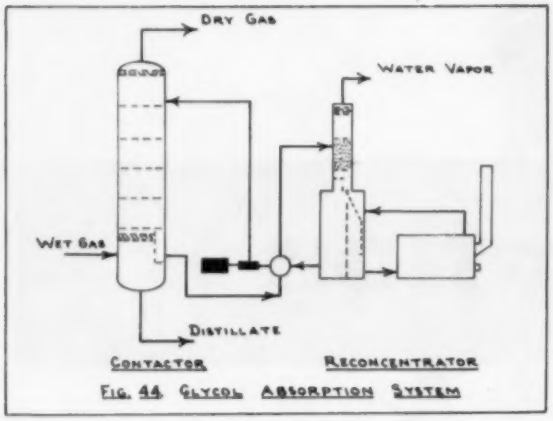

FIG. 44 GLYCOL ABSORPTION SYSTEM

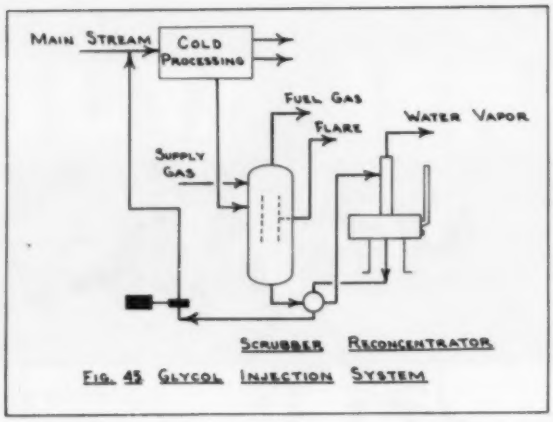

FIG. 45 GLYCOL INJECTION SYSTEM

particles. Many extractor element designs are not effective. Free drain of an extractor element generally keeps it clean, but in certain situations a gummy residue is laid down, requiring periodical cleaning. In-place cleaning with steam can be used for many installations.

It is also common practice to use low-grade desiccant in the top of the beds, to protect the bulk of the desiccant. Usual amount of "guard" desiccant is 10 to 15 percent of bed capacity.

Glycol Absorption

Fig. 44 illustrates counter-current extraction of water from gas by glycol solution. Absorbed water is removed from the glycol by heating at low pressure. Since a closed glycol cycle is used, losses of the chemical are attributable only to that absorbed in equilibrium with the gas and that carried over in the absorber. With effective mist extraction, carryover losses to the main gas plus that lost to water vapor in the reconcentration still is around 0.1 gal per MMscf of gas processed. It is essential, of course, that there be no leaks in fittings and pumps if losses are to be minimized.

Primary factors affecting dewpoint depression are glycol concentration, number of contacting stages, contacting efficiency, circulation rate and contacting temperature. Maximum practical depression attainable decreases with decrease in temperature. For example, dewpoint reduction of 95 F may be reached at a 100 F contact temperature, while an 80 F reduction would be realized at a 50 F contact temperature.

At least five contact trays are needed in the absorber when high dewpoint depression is required. Almost all water must be removed from the glycol, to a 99+ percent purity. This is accomplished by high regeneration temperature . . . at least 400 F for triethylene glycol. Use of a small amount of stripping gas in the glycol reconcentration section provides higher concentration, enabling greater dewpoint depression.

Two circulating pumps are usually used, to overcome the inherent problem of mechanical failure. These pumps can be operated at the same time to insure full-time dehydration. Filtering of the glycol is particularly important to minimize pumping difficulties. Best location for the filters is immediately upstream of the pumps.

Reconcentration section. Fuel requirements are reduced by a glycol feed-glycol product heat exchanger in the reconcentration section. It should also be noted that when the still is not refluxed by external cooling that heating the glycol above 260 F will cause excessive still top temperature and consequent high losses.

The heating system shown in Fig. 44 is somewhat more costly than those generally used. The less expensive units consist of a fire tube in a glycol bath, located directly under the still. An external reboiler such as is shown permits a relatively high circulation rate over the tubes, reducing glycol decomposition occuring at the elevated temperatures necessary for high dewpoint depression. Larger heating surface areas also reduce surface temperatures, minimizing glycol decomposition.

External reboiling also reduces possibility of distillate . . . which may be dumped with rich glycol from the absorber . . . of getting into the heating section. Decomposition has not been found a problem at normal regeneration temperatures of 375 F for triethylene glycol and 325 F for diethylene glycol.

Foaming of glycol is not usually a problem at normal temperatures used. But in some instances . . . particularly at relatively low operating temperature . . . an impurity will cause foaming by altering the glycol surface tension. A surface active chemical may be added to correct the situation. Or, the critical impurity may be removed by an adsorbant such as activated charcoal.

Alcohol Injection

Alcohol can be injected into a gas stream to lower the temperature at which hydrates would form. Since alcohol vaporizes into the gas it cannot, however, readily be recovered and is therefore seldom injected continuously. A definite advantage of alcohol over many inhibitors is that it will . . . under many conditions . . . cause hydrates to decompose.

Methyl alcohol is frequently used because it is one of the least expensive inhibitors, thus the most economical for expendable use. For example, a slug of methyl alcohol can be injected into a pipeline to clear a hydrate block. Temporary injection may permit operations to be continued while primary difficulties are being corrected, or may be practical for short periods of low ambient temperature.

Glycol Injection

Gas containing an adequate amount of glycol can be cooled to the temperature at which the glycol-water solution would freeze, without hydrate trouble. A scheme for glycol injection is shown in Fig. 45. In this system glycol is pumped into the warm gas stream, the gas processed at low temperature with glycol solution then removed and reconcentrated. The single contact made will cause a definite dewpoint depression, but only about 20 F is realized because of the low final contact temperatures in such systems.

A scrubber is incorporated into the system shown, to remove distillate from the glycol prior to entering the heating section. Thus, should the high-pressure dump

valve hang open, the reconcentrator is protected. This scrubber also provides surge capacity and permits a by-pass to be placed around the reconcentrator. This enables maintenance without shutdown of the entire plant.

Glycol will not decompose hydrates . . .it only inhibits formation. Hydrate formation must therefore be prevented by glycol in solution with any condensed water. Using a fairly steady injection rate and reasonable length of pipe for mixing before low temperature is reached will, however, permit excellent operation to be realized except in unusual situations.

A horizontal tube bundle cooler often presents a problem. Glycol will frequently separate from the gas stream at the cooler inlet, flowing on through a few of the tubes, commonly near the bottom. Although a 40 F dewpoint depression will usually be realized due to glycol contact with the gas at high circulation rate and the elevated contact temperature, this depression is often inadequate to prevent water condensation and hydrate formation in most of the tubes. Typical operation resulting from this is adequate initial cooling, followed by gradually rising cooler exit gas temperature, stabilizing at a value considerably higher than needed for design operation. In addition to reducing heat transfer, hydrates formed in the cooler often cause trouble by getting into downstream equipment.

To correct or avoid such hydrate problems, it is necessary to secure good glycol distribution in the exchanger or to realize sufficient dewpoint depression to prevent water formation. Satisfactory glycol distribution in the exchanger is seldom realized.

To effect appreciable dewpoint depression in some systems, it is desirable to inject glycol at one point, remove the solution, and inject a new lean solution. At very low operating temperatures it's necessary to avoid freezing by maintaining a solution with *sufficient water in the glycol.* Pure glycol freezes above 0 F; a water-glycol solution can be cooled well below that point.

Protection against low atmospheric temperatures is necessary in northern areas. Here particularly, it is best to realize a constant dilution throughout the operation. This is difficult, though. Also, there is little temperature difference between the boiling points of rich and lean solutions. If a high water content solution is allowed to build up in the system, a small temperature rise will generally overload the still, causing loss of gylcol. Sidestream regeneration has been used satisfactorily.

Glycol is partially soluble in hydrocarbons. A definite loss will thus occur when contact is made with distillate or gasoline. The loss is not very significant in lighter liquids, usually less than 0.5 gal per 100 bbl. It will be considerably higher if the distillate has a heavy end content. Solubility is particularly high in liquids such as benzene.

If heavy ends are to come in contact with glycol, it is wise to determine solubility by laboratory tests, to see if losses would be excessive. In making an analysis, it should be kept in mind that losses will exceed that due to solution . . . separation will not be completely effective in commercial operation.

It is frequently practical to separate heavy ends from the gas stream and by-pass them around the glycol injection and recovery system. Sumps and return facilities for product tanks where glycol content may be appreciable are often worthwhile . . . considerable recovery is possible from tanks where relatively long residence time effects thorough separation of entrained glycol. Solubility decreases with temperature, but at low temperatures an emulsion may form that will prevent effective separation.

Which glycol should be used? Ethylene glycol is less soluble in hydrocarbons than either diethylene or triethylene glycol, the last named being the most soluble. The ethylene glycol is thus preferred in injection systems. One disadvantage is, though, the special still requirement which must be incorporated to prevent excessive loss of the more volatile ethylene glycol from the system.

Other operating problems. It is not possible to contact a final product (liquid) with glycol that has contacted high-pressure gas. The glycol will contain enough gas in solution to increase product vapor pressure. Also, quite peculiar emulsions have been observed, forming particularly at low temperatures. For example, glycol dumped from a cold high-pressure separator into a distillate-containing vessel has been found to pass across the top of the vessel, "floating" on the lighter distillate.

Salt precipitation is often a serious problem. Solubility of salt decreases with increasing temperature in a glycol system and will cake out in heater tubes and exchanger bundles, reducing heat transfer or causing overheating in a fired system. Thorough removal of salt water from the process stream is necessary to minimize operating difficulties.

High Dewpoint Depression

Special facilities are required to attain the degree of water removal needed for operation at extremely low temperature. Operation of turbo-expander at low temperature is one example of when a minimum amount of water must be in the gas stream.

Glycol injection with controlled composition of the glycol-water solution is limited to about −40 F, while glycol absorption is usually limited to above 0 F. With a low gas velocity, high dewpoint depression is possible with dry desiccant, but when towers are switched an appreciable amount of water usually leaves the unit.

Two dehydration units can be used in series to provide the water removal required. Two desiccant beds can be placed in series or glycol dehydration used as the first step, to remove the bulk of the water prior to the desiccant bed. Satisfactory operation down to a −200 F dewpoint is possible in this manner.

Special attention must be paid to the manner in which towers are switched to reduce to a minimum the flow of wet gas from a vessel when it is placed onstream. Also, it is necessary to remove components such as hydrogen sulfide and carbon dioxide prior to operating at low temperatures.

Heat Reduces Hydrate Problems

Heat is sometimes used to prevent hydrate trouble, for example, in short transmission lines. Primary disadvantage is that heat is soon dissipated from a pipeline and is therefore not effective for long runs. Fuel is expensive. And, if free water is separated at an elevated temperature the gas will contain an excessive amount of water.

Heating facilities at the inlet of a plant often are good protection against cold weather operating problems. Hydrates can be avoided in a glycol injection system, or in a dry desiccant plant where a pressure drop is taken at the entrance to provide motive power for the regeneration gas.

Dehydration of Liquids

Stripping with gas is generally the most economical method for drying liquids when continuous service equipment is justified over intermittent. Use of gas to remove water from absorption oil at low pressure in a stripping still is a typical example . . . a very small amount of gas is required since the gas will hold considerable water at low pressure.

One of the most important steps in dehydrating liquids is removal of free water. Free water in a wet liquid charged to a dehydrating facility would otherwise be removed preferentially, before the water in solution. Thorough filtering is usually justified, to reduce dehydrating equipment required and the cost of operation. It is not unusual for a filtering

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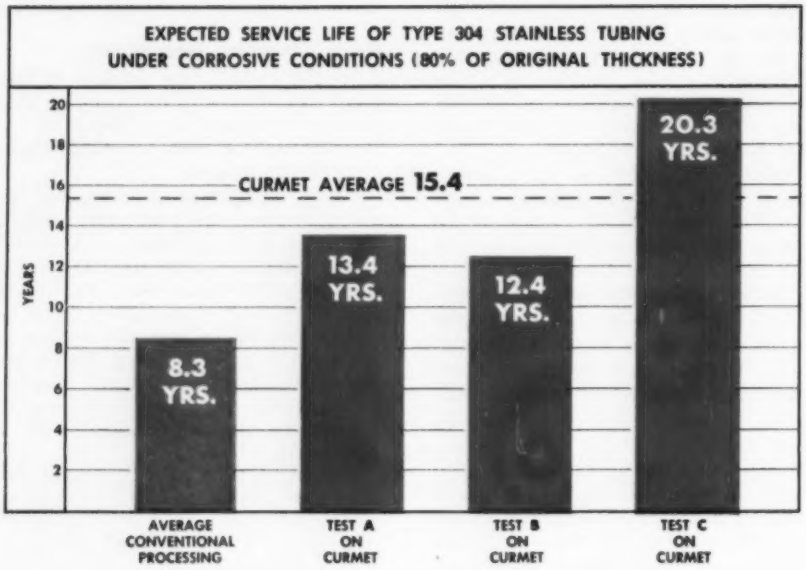

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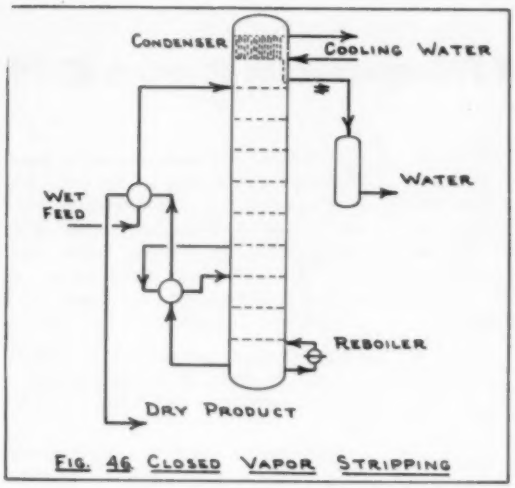


FIG. 46 CLOSED VAPOR STRIPPING

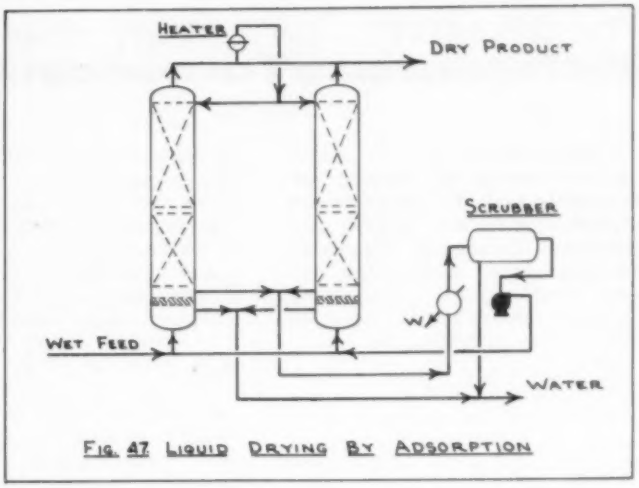


FIG. 47 LIQUID DRYING BY ADSORPTION

(coalescing) system to reduce water content of a stream by half.

A gas stripping system, used for water removal from a light hydrocarbon, is shown in Fig. 46. Cooling overhead removes water which has been stripped from the liquid. Loss of product is avoided and there is no contamination since no foreign gas is introduced. Use of a side stream heat exchanger as shown is generally practical to recover heat from the bottoms. It could not be used, of course, if the liquid to be dehydrated were nearly a pure component . . . there would be but little temperature difference across the column.

Liquid drying by adsorption is shown in Fig. 47. Such dry desiccant systems have found wide use for drying LPG flowed from underground storage. Filters can be provided in the bottom of the contactors, as shown, to remove free water. A small stream of dehydrated product is heated and passed through the bed not in use for removal of water. Several schemes have been used for vessel location in the system and for control of liquid dehydrators.

Next Month in Modern Gasoline Plants: "Gas and Water Treating" will be described and discussed by author Dave Vondy.

New Sulfur Removal-Recovery Process

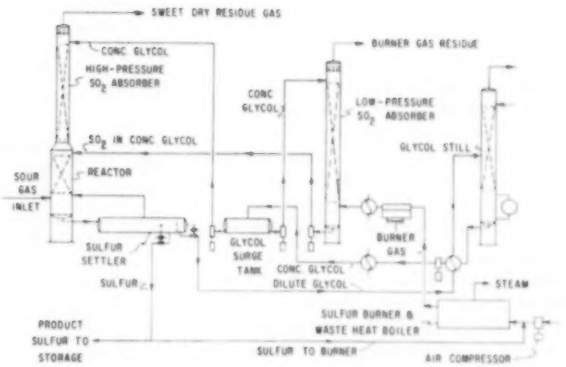
"A more efficient process that costs less to build and operate" for removal and recovery of sulfur in natural gas was described by Laurance S. Reid and F. Mark Townsend of Oklahoma University's School of Chemical Engineering, at the NGAA's Rocky Mountain Regional Meeting, on September 18.

Dubbed the "Townsend Process," because of the reaction mechanism $2H_2S \pm SO_2 \rightarrow 3S + 2H_2O$ discovered by Dr. Townsend, the process provides for the simultaneous sweetening of sour gas and conversion of the H_2S to water and elemental sulfur. Licensed by the authors to Hudson Engineering Corporation, it is claimed to be "insensitive to carbon dioxide in the process stream, provides for effective dehydration of residue gas, adaptable to a wide range of H_2S concentration in the gas stream, and with recovery efficiency that may exceed 95 percent.

Reaction occurs in the lower portion of a combination reactor-absorber tower. Catalyst and reaction medium is either tri or diethylene glycol, concentration of which is maintained sufficiently high to absorb water formed by the reaction. Sulfur dioxide is kept in some excess to minimize SO_2 formation; since SO_2 is readily soluble in glycol solution, SO_2-free glycol is used to recover the excess from the residue gas stream. Sulfur is essentially insoluble in glycol, hence is recovered by settling reactor "bottoms."

The diagram shown is for treating sour pipeline gas.

A limited number of copies of the paper are available from Natural Gasoline Association of America, 421 Kennedy Building, Tulsa 3, Oklahoma. Full description and cost data are programmed for later publication in *The Refining Engineer*.



Townsend Sulfur Recovery Process as applied to sweetening of pipeline gas, with subsequent recovery of elemental sulfur.

However, the authors claim that the process can be effectively used in a modified form to process acid gas from an amine plant, for sulfur recovery.

Cost and operating studies are still in the early stages. Expectations are, however, that the Townsend Process should be quite competitive in all respects, according to Reid and Townsend. Full evaluation of economic aspects in a pilot plant or semi-commercial unit is planned for the near future.

Maintenance Turnaround Planning Pays Off

Small refineries are not usually equipped with specific planning staffs to guide the work of maintenance turnarounds, even for major process units. Regardless, Turnaround Maintenance Planning can be accomplished, with good results. Case in point: Sinclair Refining Company's 25,000 bbl per day refinery at Sinclair, Wyoming.

Built up during a 15-year period, the system used is both efficient and practical, according to George M. Allen, speaking at the WPRA's Rocky Mountain Regional Meeting on September 25, at Casper, Wyoming. "It compares favorably," he said "with specific planning group practice, through comparison of downtime and hours onstream."

Planning has to be good. About 250 miles from a major supply point and available skilled labor, the refinery is forced to maintain its own supplies and equipment, as well as do the work with its own forces. Specialties, such as regenerator lining or repair of electrical generating facilities are contracted out, but the keynote is on use of the refinery's own maintenance force. This provides all skilled workers . . . a limited local labor market gives only unskilled help of temporary nature.

Turnaround maintenance consists of repairs to a 10,000 bbl per day fluid catalytic cracking unit, its stabilization and alkylation units, two 100,000 lb per hr 600# boilers, auxiliary water treating facilities, and all electrical facilities.

Shutdowns are scheduled for once a year, with about two weeks set aside for simultaneous repair of the units. Shutdown is tentatively set for the first two weeks of May, adjusted as the time approaches for inventory situation, materials and manpower availability, etc.

Turnaround planning is a year-around, every-day effort divided into three basic stages . . . pre-preplanning, preplanning and the actual turnaround. Mechanics of planning is a joint operation with management directing all supporting departments.

Pre-preplanning starts just as soon as inspection and maintenance reports are available from the last turnaround. A management meeting . . . attended by plant managers and staff representatives from operating, engineering and mechanical departments . . . reviews the last turnaround, forecasting what parts of each unit may need major attention on the next or even later turnarounds. This tentative schedule, based on known wear rates, line section analysis, operations studies and foremen's recommendations, is a guide for further study by individual departments.

Until start of second-stage planning, notes are kept at the units on what will require attention. These notes are logged, also given to the mechanical department at daily morning meetings. Work is thus scheduled for either the turnaround or to be done during day-to-day operations. The notes, plus work decided on during and subsequent to the pre-preplanning meeting make up the skeleton outline for the preplanning step.

About 30 days before turnaround, the skeleton outline is reviewed, brought up to date, and turned over to the mechanical department. Work lists are made for each unit, subdivided into sections of the unit, then subdivided into sections of the unit, then subdivided again into individual jobs. The lists are extensive . . . including details such as safety notes, blinding schedules, manway schedules, work to be done by operators, technical men, individual mechanical crafts, materials requirements and where located, references to drawings, reports, etc.

Operating unit supervisors play a big part at this point, noting jobs to be done, notifying maintenance people on practical difficulties, and determining relative importance so that some jobs might be deferred until later date.

Preplanning begins at this point. The Master Plan is consolidated, and a meeting held with attendance including all people in charge of or affected by the turnaround. Work lists are reviewed, assignments made, and questions answered. Joint responsibility still prevails, but actual work comes under jurisdiction of the resident engineer and master mechanic, who coordinate staff and line functions and generally keep the ball rolling toward turnaround.

These steps are then taken:

- **Mechanical forces are enlarged** by reducing operating men to a minimum, transferring them to mechanical labor. Student mechanics are set up to Class A mechanics. All mechanical employees possible are assigned turnaround work. No vacations or leaves are granted for the two weeks before, during and two weeks after scheduled shutdown.
- **Equipment and tools are put in good condition** and moved to the units before shutdown, to the immediate vicinity of the work where possible. Rigging, scaffolding, welders, hoists, etc. are distributed to the units and set up several weeks in advance where interference with operations will not occur.
- **Replacement equipment is spotted** at or close to point of installation when it is reconditioned and ready for service.

Equipment such as exchanger bundles, slide valves, large valves, piping sections, etc., are installed as whole units where feasible. Spare units are therefore carried for all items with high wear rates. Displaced equipment is reconditioned between turnarounds. Work is standardized to a high degree, even to the extent of assigning men to the same tasks for each turnaround, to enhance fast and correct installations.

- **Replacement materials,** such as valves, fittings, pipe, wear pads, plates, are all spotted as close as possible to known points of use. Sizes and types are scheduled, and it's a craft supervisor's job to have the materials needed at job site before shutdown.
- **All elevator movements possible** in the eight-floor freight-passenger unit at the 13-story cat cracker are made in advance of shutdown, to minimize bottlenecks.

Final preplanning meetings are held about a week before shutdown to check all work lists and sequence of performance. Feeding overtime workers, time tables, craft problems, work hours and bottlenecks are all considered.

Summing up, Allen said that actual planning work has been standardized to the point of being routine. One of the prime values, he stated, is that the master mechanic is freed from minor decisions and can devote his thinking to overall coordination.

With the complete, "everybody's responsibility" concept used for turnaround planning at the refinery, full-year, uninterrupted unit operation is better assured, according to Allen. Further benefits cited are closer cooperation between operating and mechanical departments, better teamwork among various crafts, easing of problems in materials and equipment supply, and necessary accumulation of data that leads to still better turnarounds in the future.

Condensed from "Maintenance Turnaround Planning," by George M. Allen, Sinclair Refining Company, Sinclair, Wyoming. Presented to Western Petroleum Refiners Association's Rocky Mountain meeting, Casper, Wyoming, September 25, 1958.

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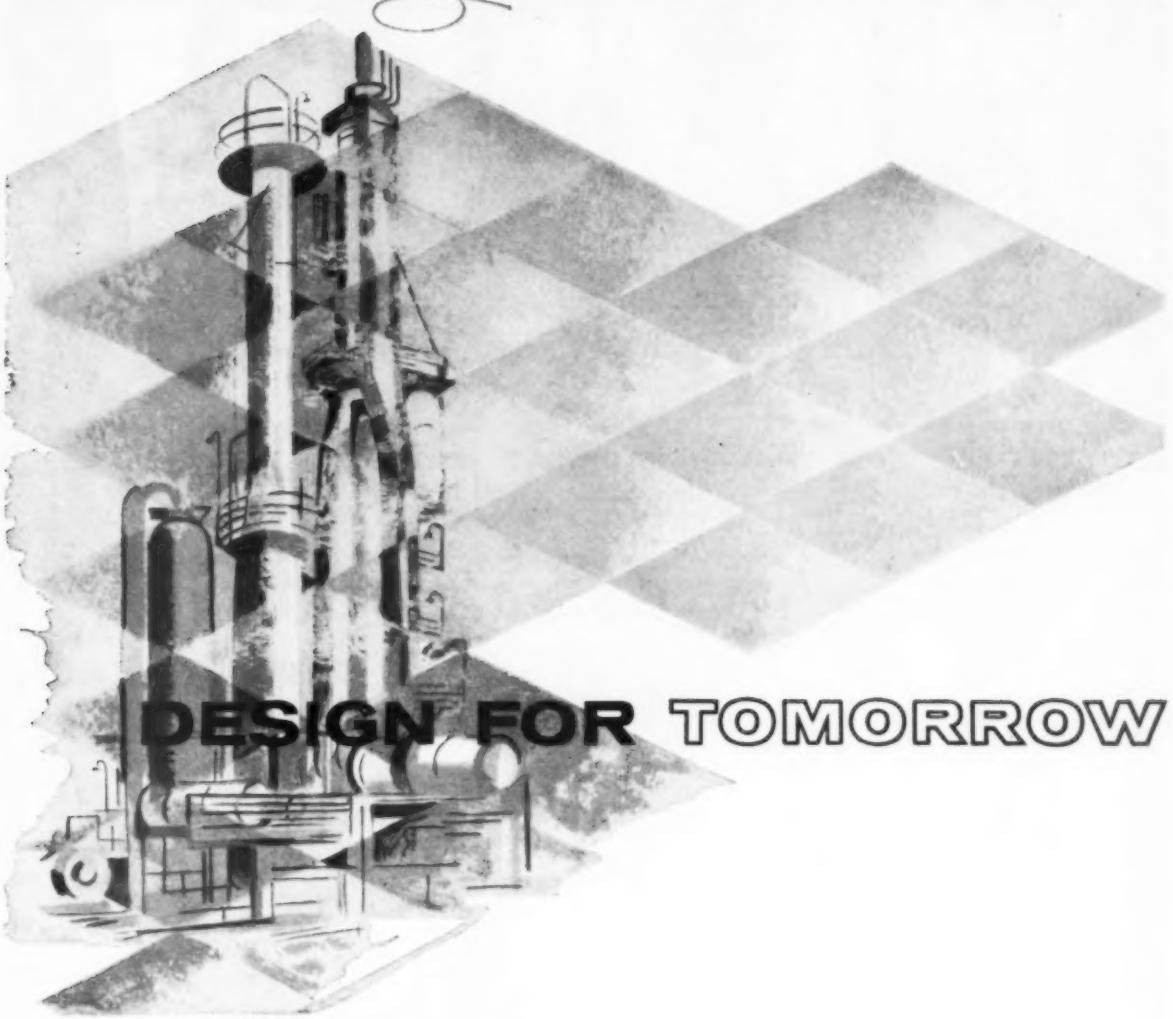

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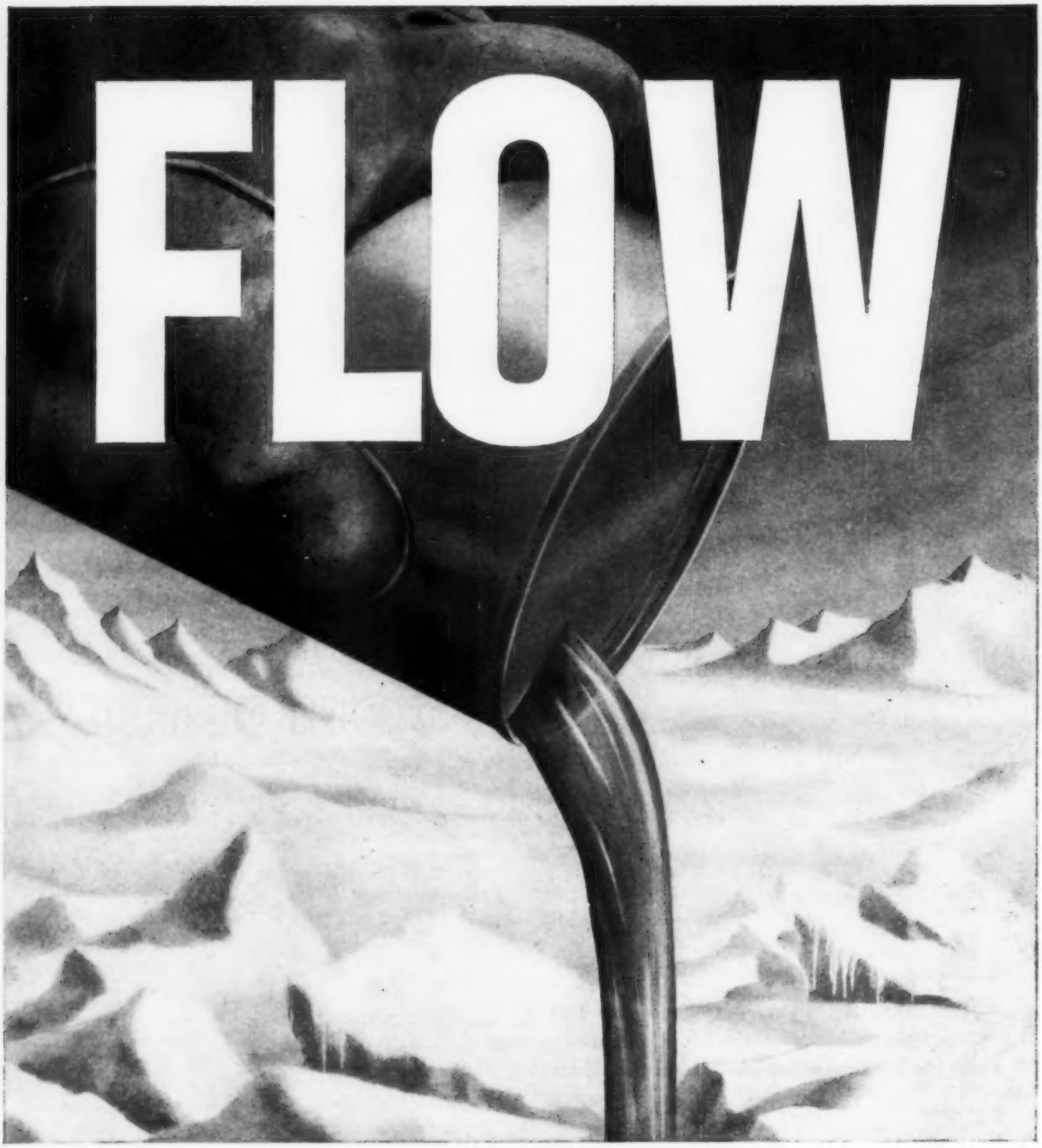

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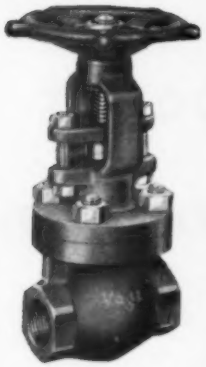

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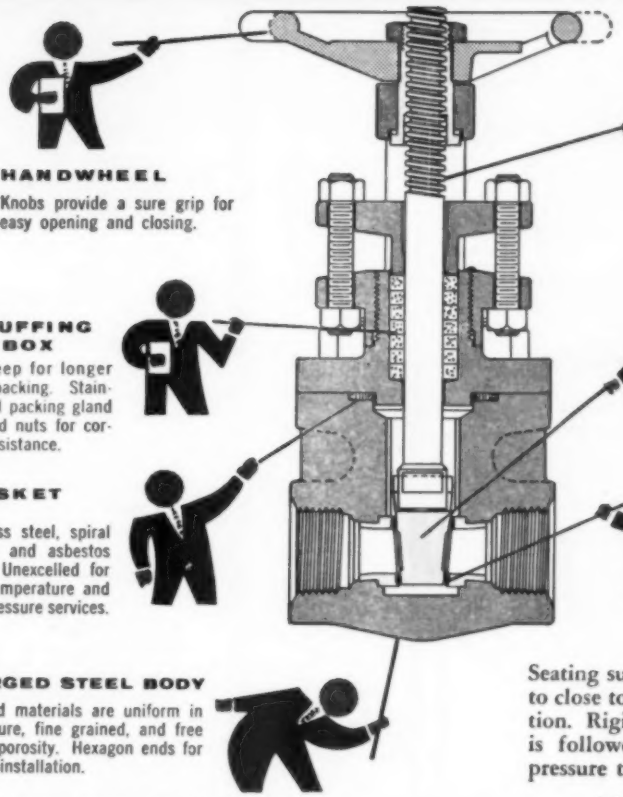

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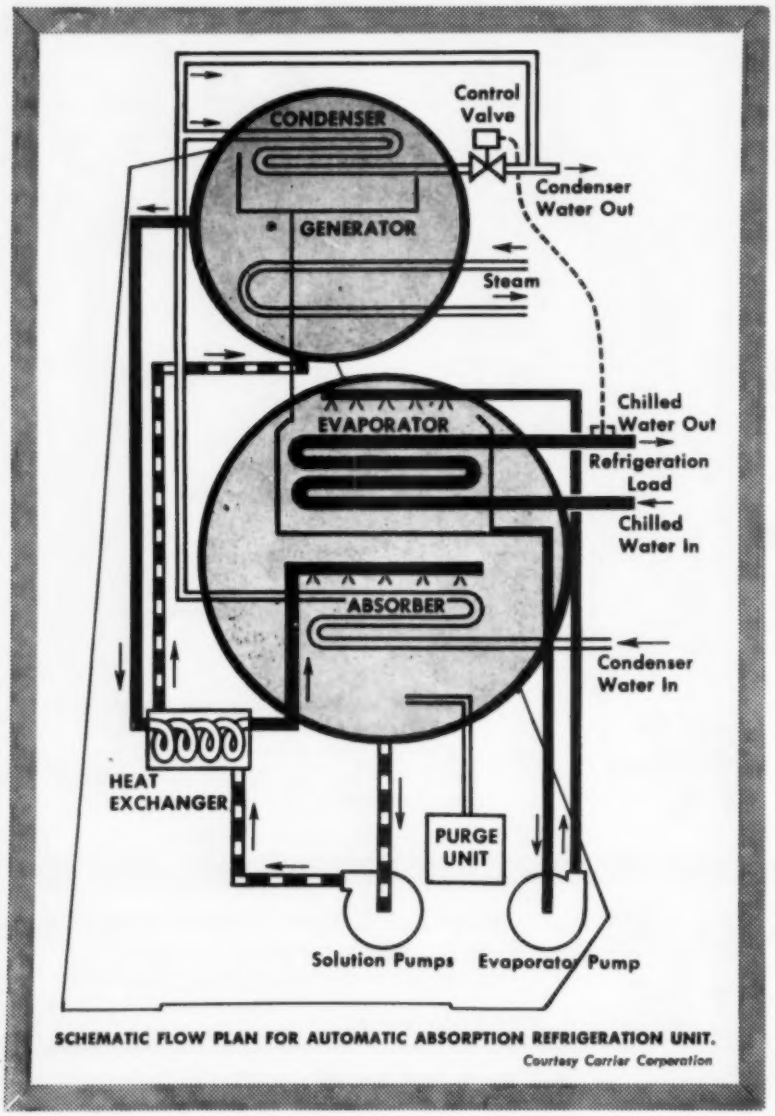

SCHEMATIC FLOW PLAN FOR AUTOMATIC ABSORPTION REFRIGERATION UNIT.
Courtesy Carrier Corporation

ABSORPTION REFRIGERATION is coming into increasing importance for providing higher tonnages of cooling and refrigeration in the process industries. Provided here is an outline of check points for maintenance of these units and tips on how a preventive maintenance program can be established.

Principles of Operation

Understanding of the equipment and its functions is, of course, the first step in establishing a preventive maintenance schedule. The absorption machine illustrated has no moving parts other than the evaporator and solution pumps. It uses 12 psig steam, requiring about 20 lb per ton of refrigeration, chills water to 40 F.

The basic absorption cycle is based primarily on two principles:

1. It requires a solution (lithium bromide or other) with ability to absorb water vapor.

2. Water will boil or flash cool itself at low temperatures when subjected to a high vacuum.

These two principles are used in the absorption machine to obtain refrig-

How to Determine Drainage Frequency

Given:

Recirculation Rate..... = 100 gpm
Windage loss = 1 % recirc. rate..... = 1 gpm
Evaporation loss = 4% recirc. rate... = 4 gpm
Max. Permiss. cycles of concentration = 3
Capacity of Circuit..... = 10,000 gal.

Required:

Frequency of draining or maximum hours of operation before draining the circuit.

Solution:

$$\text{Time in Hours} = \frac{2.3\,\frac{Q_4}{Q_2}\,\log\,\frac{\left(1-\frac{Q_1}{Q_2}\right)}{\left(C-\frac{Q_1}{Q_2}\right)}}{60}$$

Where Q_4 = Capacity of circuit in gallons = 10,000
Q_2 = Windage loss..... = 1 gpm
Q_1 = Make-up water = evaporation loss + windage loss..... = 5 gpm
C = Permissible cycles of concentration = 3

Therefore:

$$\text{Time in Hours} = \frac{2.3\,\frac{10{,}000}{1}\,\log\,\frac{\left(1-\frac{5}{1}\right)}{\left(3-\frac{5}{1}\right)}}{60}$$

$$= \frac{23{,}000\,\log\,\frac{(-4)}{(-2)}}{60}$$

$$\text{Then Time in Hours} = \frac{23{,}000 \log 2}{60} = 115 \text{ hours.}$$

eration in a shell maintained at a high vacuum. A portion of the water flashes and thereby cools the balance of the water. Water vapors are then absorbed by the absorbing agent.

The lower shell, called the absorber shell, contains the absorber and evaporator. The upper shell, referred to as the generator shell, contains the generator and condenser. Evaporator water is pumped from the evaporator bottom and sprayed over the chilled water tube bundle. The water is cooled by flashing of the evaporator water on the outside of the tubes.

The water vapor formed in the evaporator is absorbed by the solution being sprayed in the absorber. The absorber pump moves solution from the bottom of the absorber to the solution spray header. Weak solution is pumped through the heat exchanger where steam inside the generator tube bundle concentrates the solution by boiling off water absorbed in the lower shell. Concentrated solution returns through the heat exchanger to the absorber.

Condenser water first goes through the absorber coil where it picks up heat of dilution, then goes to the condenser where it picks up heat of condensation. Water vapor boiled off in the generator is condensed in the condenser and the condensate returns to the evaporator.

Maintenance Schedules

The tabulated outline and other similar types have been used by the writer in refineries, gasoline, petrochemical and power plants. Many variations may be used, set up in accordance with the user's specific needs. As indicated, monthly, quarterly, semi-annual and annual checks are suggested for components. Only during the annual check does the shutdown have to be complete, barring emergencies.

Firms who may maintain only a small maintenance crew or a crew that may be inexperienced with this type of equipment may find it advantageous to use the available "planned maintenance" which may be worked up for each installation by manufacturers.

Water Scaling Prevention

We will not go into the actual chemical treatment of water as such, but rather into the draining and bleed-off methods to prevent scaling and corrosion in the cooling water system. Reasonably clean water is most important in all processes, otherwise it can do untold damage.

As water passes through a cooling tower or spray pond, dissolved solids in the water become concentrated. The evaporated water must be replaced by make-up water. For quick estimation, quantity of water lost by evaporation is about one percent of the recirculation

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- Positive flange cost economy.

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- Inherent reinforcement.

IN COMBINATION:

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rate per 10 F temperature drop through the tower.

Windage or drift loss (loss of fine droplets of water entrained by circulating air) tends to limit, however, the degree of concentration. The higher the windage loss, the lower the degree of concentration. Reversed, the lower the windage loss, the higher the degree of concentration. The following may be taken as typical windage losses based on the rate of circulation.

Spray ponds	= 1.0 to 5.0%
Atmospheric cooling towers	= 0.3 to 1.0%
Mechanical draft towers	= 0.1 to 0.3%
Evaporative condensers	= 0.0 to 0.1%

In most cases windage losses should be estimated, since rigorous calculation is difficult. When there is doubt concerning what windage loss value to use, select a low value to be conservative. On applications where scaling is a serious problem, assume that there is no windage loss; it is better to select too low a value than too high a value for windage loss.

Where water has an excessive degree of oversaturation of scale-forming minerals, it is necessary to control the cycles of concentration within fixed limits. Where the natural windage loss fails to limit the cycles of concentration, it is necessary to supplement the windage loss by means of blow-down or bleed-off. The bleed-off should take the form of a continuous bleed of water from the system. Amount of bleed-off required depends upon the character of the water and temperature conditions encountered in the heat exchanger.

How to Calculate Drainage Frequency

Continuous bleed-off is preferred over periodic draining of the recirculating water circuit. However, there may be instances where periodic draining is more practical, especially where bleed-off is so small that orifices or valve openings become plugged with dirt or other matter. On page C-33 is an example of how to determine the drainage frequency of a system.

This particular circuit, therefore, needs to be completely drained after each 115 hours of operation if the permissible cycles of concentration are not to be exceeded.

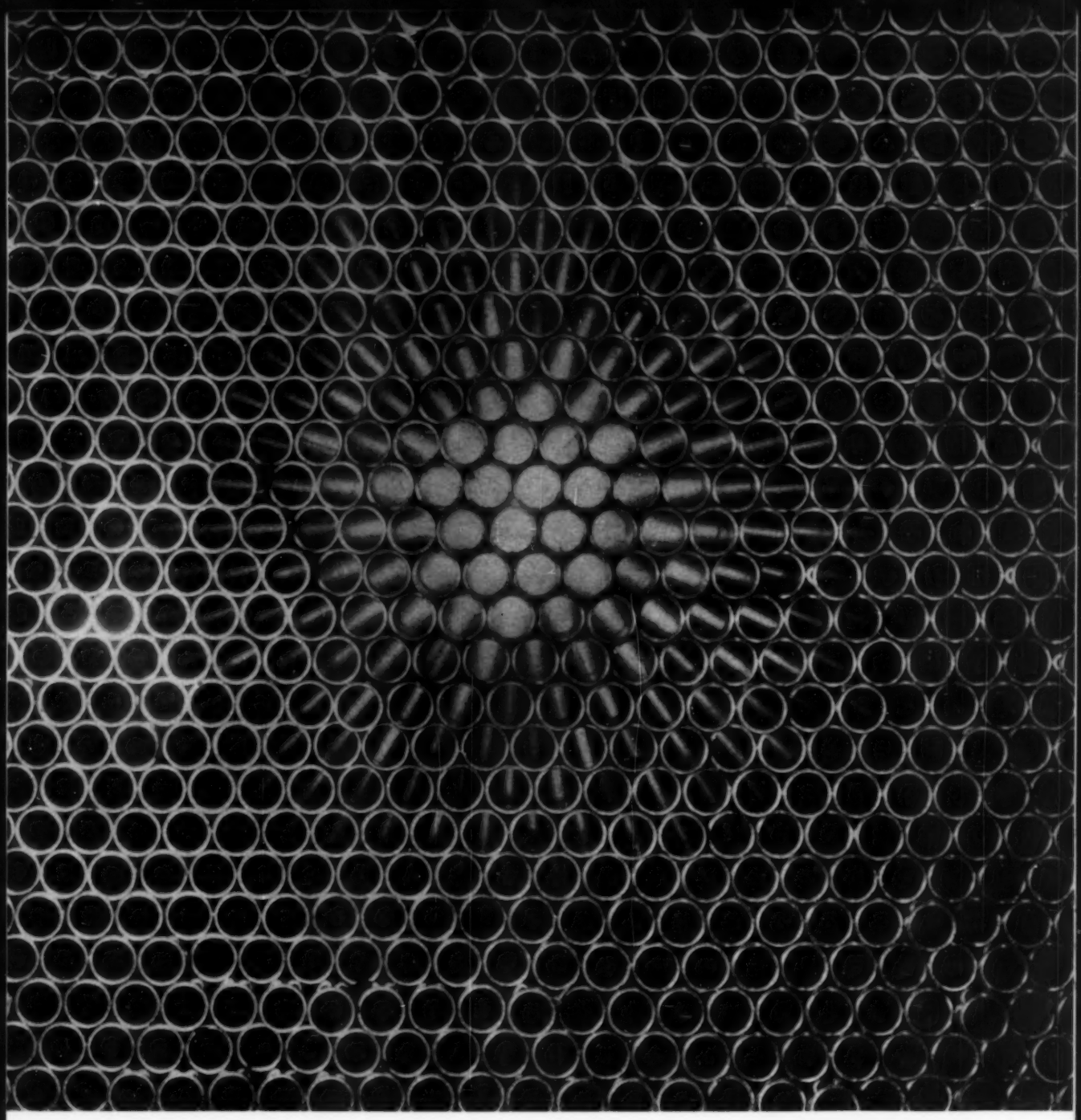
It should again be emphasized that continuous bleed-off is to be preferred over periodic draining. In either case, total water requirements are about equal. The method to be used will depend upon the ease with which bleed-off can be controlled. ★ ★ ★

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Inspection Procedure for Absorption Refrigeration Units.

	Inspection Frequency			
	Monthly	Quarterly	Semi-Annual	Annual*
1. Absorber, inspect including condenser tubes.				√
Controls				
2. Pressuretrol, check and adjust		√		
3. Tee Restrictor, check and adjust			√	
4. High level cut-out, check and adjust			√	
5. Purge level control, check for proper operation and clean probes.		√		
6. Control point adjuster, clean and adjust		√		
7. Low Temperature cut-out, check and adjust				√
8. Strong solution thermometer, check and calibrate				√
9. Vapor condensate thermometer, check and adjust				√
Filters, Strainers, Traps, etc.				
10. Clean steam condensate trap			√	
11. Clean steam strainer			√	
12. Clean purge filter and filter line				√
13. Clean cooling tower water pump suction strainer		√		
Switches and Relays				
14. Manual purge switch, check for correct operation			√	
15. Control relay, check for correct operation	√			
16. Start-stop switch, check for correct operation			√	
17. Start-stop switch, replace lights as required	√			
Seal Checks				
18. Check for seal leakage: Generator, absorber and evaporator pumps		√		
19. Perform a standing seal water check for loss of seal water			√	
20. Clean and flush seal water tank, lines and seal chamber				√
21. Remove and clean purge tank and purge sight glass				√
Pumps				
22. Lubricate pump motors, (1) 2 solution pumps, (2) Evaporator pump			√	
Valves				
23. Ball check valve in evaporator water to seal tank, check operation		√		
24. Capacity control valve, check and adjust			√	
25. Capacity control valve linkage, lubricate	√			
26. Valve diaphragms, inspect and replace if necessary				√
Solution and water tests				
27. Check concentration of solution		√		
28. Check evaporator water at correct solution concentration for spillover	√			
29. Establish proper quantities of solution and water			√	
30. Perform an operation test for vacuum leaks		√		
31. Perform a standing vacuum test				√
32. Test machine for leaks under pressure				√
33. Inspect spray nozzles, (1) evaporator, (2) solution			√	
34. Protective painting		(as required)		
35. Miscellaneous additions depending on specific installation		(as required)		

*With complete plant shutdown.



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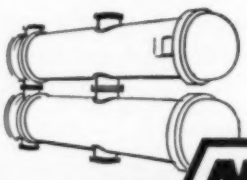

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This report gives guides to better processing and quality...

WHAT CHEMISTS HAVE LEARNED ABOUT ASPHALT

Dr. R. N. Traxler
Supervisor, Asphalt Research

J. W. Romberg
Research Project Engineer

Texaco Research and Technical Department
Port Neches, Texas

FOR A LONG TIME it was common practice to speak of asphalts as mixtures of hydrocarbons of widely varying molecular weights. But, from studies made in recent years, it has become evident that a high percentage of the molecules in asphalt contain elements other than carbon and hydrogen, and that we are dealing with an extremely complicated aggregation of organic compounds. Thus far we have arrived only at the point of attempting to isolate and identify chemical types.

Bulk of the evidence now available indicates that a full understanding of the chemical composition will not be easily and quickly obtained. We know, however, that fractions of about the same average molecular weight, obtained from various asphalts, may have greatly different viscosities, which indicate completely dissimilar compositions.

Half a century ago Clifford Richardson in his book "The Modern Asphalt Pavement" discussed his concept of the composition of asphalt. He mentioned the straight and branched chain hydrocarbons as well as the saturated and unsaturated cyclic hydrocarbons, but not ring structures with long side chains. Richardson recognized the presence of sulfur, nitrogen and oxygen compounds in asphalt but erroneously considered them of little importance.

The theory that highly condensed aromatic rings probably predominate in asphalts now appears to be unsound. The molecular carbon to hydrogen ratios recently reported are not high enough for the molecular weights found to support that theory. For example, decacylene (C_{36} H_{18}) has a molecular weight of 450 and a C/H of 2.0, but asphaltenes have a C/H of 1.0 or less and molecular weights of the order of 2500 to 5000. Also, it should be noted that polycyclic compounds such as picene are insoluble in solvents commonly used for asphalts. Thus, the presence of highly condensed aromatic rings in asphalt in appreciable quantity seems unlikely.

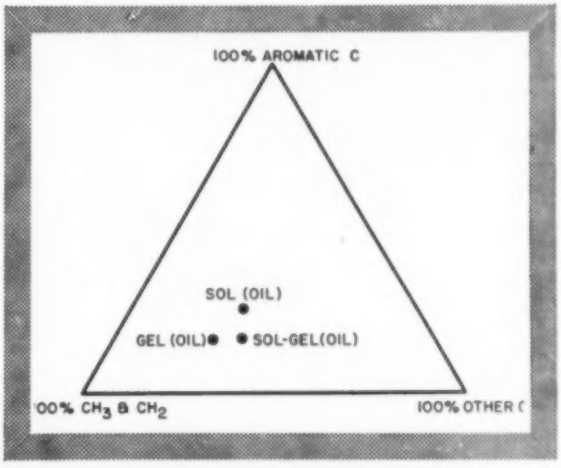
Carbon in aromatic ring structures has been found by infrared analysis in most asphaltic fractions. Amount of such carbon is greatest in heavier fractions of the asphalt. Naphthenic rings have been found especially in the lower molecular weight fractions.

Polymethylene chains appear to be present in fairly large quantities, but length does not vary as much as one might suppose. Chains up to 13 methylene units have been reported. Chains are generally longer in straight-run asphalts and shorter in cracked or air blown asphalts. Number of CH_3 groups found indicates some chain branching. Alkyl chains are probably present both as side chains with CH_3 terminals and as linking units in spatial configuration such as diphenyl ethane.

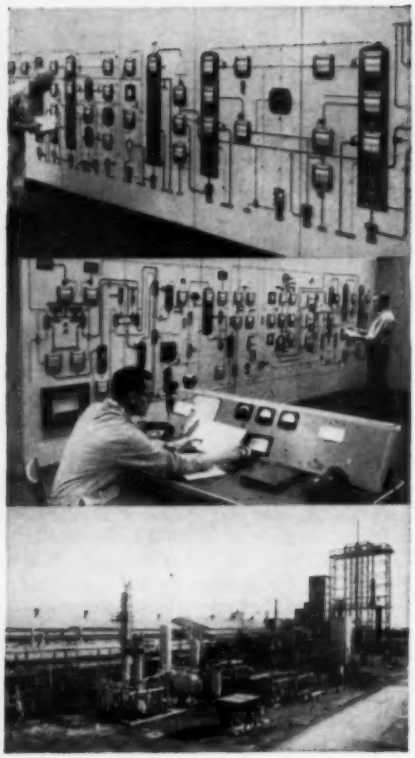
Fractionation of Asphalt

A number of procedures have been proposed for the fractionation of asphalts. One of the more recent and practical involves the precipitation of the higher molecular weight materials or "asphaltics" by hot 1-butanol. The butanol-soluble oils are then fractionated by means of cold acetone which dissolves the "cyclic" compounds and precipitates the "saturated" or "paraffinic" materials. This procedure has been called Component Analyses.[1] The amounts of the three components thus obtained give a considerable insight into the general chemical composition of an asphalt, which in turn influences its colloidal, rheological and other physical properties. These relations have been discussed recently.[2, 3]

O'Donnell's pioneering work[4] did much to stimulate fundamental research on the composition of asphalt. He used molecular distillation to obtain a fractionation on the basis of molecule size and silica gel chromatography to separate resins, saturated compounds and aromatics. Wax content was determined by solvent dewaxing the saturates fraction which is predominately a naphthenic oil. Long-chain paraffins were separated by the formation of urea-complexes. Alumina chromatography was used to isolate monocyclic aromatics and thermal diffusion to segregate naphtenes on the basis of the number of rings present.



Average percentage for the three types of asphalt oil fractions.



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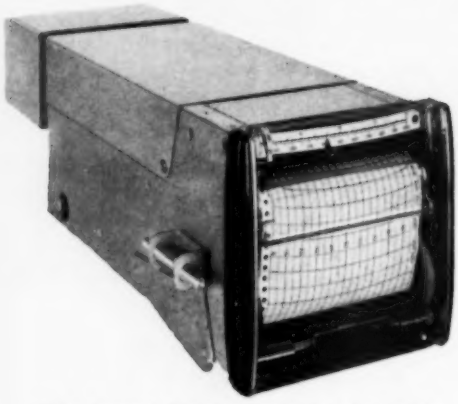

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CONSOTROL INSTRUMENTS

Types of Carbon Compounds in Asphalts

The following data by the authors[2] show the amounts of various carbon linkages found in the three components from a particular air blown asphalt.

	Weight Per cent Carbon as		
	Aromatic Rings	CH_2 (Chains)	CH_3 (Terminals)
Asphaltics	60	26	10
Cyclics	27	27	12
Paraffinics	21	40	13

Murphy[5] used the Waterman Analysis to determine the percentage of carbon atoms present as paraffins, naphthenes and aromatics in the oily fraction (malthenes or petrolenes) of asphalt. This analysis is made by measuring specific refraction before and after hydrogenation. His data follows:

		Malthenes		
Asphalt from which Malthenes were obtained	Molecular Weight	Weight percent of Aromatics	Naphthenes	Paraffins
Straight run	293	14	35	51
Straight run	448	27	24	49
Straight run	616	53	1	46
Cracked	270	36	16	48
Cracked	344	47	1	52
Cracked	350	51	2	47

These data indicate that the oil fraction of asphalts consists of aromatic and naphthene rings with paraffinic side chains, or linkages. Oils from the cracked asphalts are low in naphthene rings.

Molecular Weights

Reported values for the molecular weights of constitutents of asphalts vary from about 300 to 900 for petrolenes and from about 700 to several thousand for asphaltenes. It should be remembered that these values are averages for fractions which may vary over fairly wide ranges. In addition, there is considerable uncertainty in many molecular weight determinations. Thus, most molecular weights given for components of asphalts should be considered as approximations.

Sulfur

Sulfur appears to be concentrated in the heavier fractions of asphalt. This is illustrated by the following data on low and high sulfur content asphalts.

Asphalt	A	B
Asphalt, Wt % S	0.63	3.34
Asphaltics, Wt % S	1.02	4.84
Cyclics, Wt % S	0.66	3.56
Paraffinics, Wt % S	0.48	2.31

The asphalt B has almost one atom of sulfur for each molecule, and the heavier portion (asphaltics) contains more than one sulfur atom per molecule.

Murphy stated[5] that when the sulfur content is high, the oxygen content is low and vice versa. Recent work indicates that this may not be true for all asphaltic fractions. Garner[6] reported that thiophenes were isolated from the oily fractions of asphalt, while Spielmann[7] stated that thionaphthenes may occur.

O'Donnell[4] found that many of the aromatic fractions of asphalt contain a predominance of sulfur compounds. He considered these to be principally substituted benzothiophenes. However, even in the fractions containing an average of more than one sulfur atom per molecule, he found some hydrocarbons. Sulfur probably serves as a linking element, but its significance in the composition of asphalt is not well understood.

Oxygen

For many years oxygen was considered a minor constitutent of asphalt, a belief which was held even for air blown (oxidized) asphalts. This came about because the oxygen content was obtained by subtracting the sum of the percentages for C, H, S and N from 100. Also, it was not recognized that a small amount of oxygen (percentage-wise) could represent a large number of oxygen containing molecules. In some fractions of asphalt as much as 80 per cent of the molecules have been found to contain oxygen.

Knotnerus[8] discussed chemical methods for measuring oxygen and applied infrared analysis to the problem. Oxygen was found to be present in asphalts as carbonyl, hydroxyl, acid and ester. No ether linkages were detected. Ester groups are formed by oxidizing (air blowing) asphalts at low temperatures. At higher temperatures (475-525F) oxidation results in the formation of water and the establishment of carbon to carbon linkages. Analyses obtained by Knotnerus follows:

	Weight Percent Oxygen as				
Material Analyzed	COOH	COOR	OH	C=O	Total
Residual oil	0.00	0.15	0.10	0.05	0.30
Blown Residual oil	0.01	0.50	0.20	0.24	0.95
Residual asphaltic bitumen	0.01	0.10	0.31	0.10	0.52
Asphaltenes from residual bitumen	0.10	0.10	0.50	0.30	1.00
Asphaltenes from blown residual bitumen	0.25	1.15	0.30	0.15	1.85

Nitrogen

Ball, Latham, and Helm[9] conducted an extensive investigation of the nitrogen content of asphalt from which they concluded that most of the nitrogen in petroleum is found in the asphaltic fractions. The nitrogen is so firmly bound in these high molecular weight compounds, that upon pyrolysis, it remains in the coke. Some of the higher molecular weight materials (asphaltenes) contain as much as 2 atoms of nitrogen per molecule.

From the data which follows, Ball and his associates concluded that most of the nitrogen occurs in ring compounds.

	Nitrogen, Weight Percent		
Source	Tampico	Oregon Basin	Wilmington
Crude oil	—	0.35	0.65
Residuum	—	—	1.20
100 Penetration asphalt	0.50	0.64	—
Oils	0.05	0.13	0.60
resins	0.78	0.89	1.70
asphaltenes	1.06	1.18	2.28

It has been reported that nitrogen occurs as bases containing quinoline and pyridine rings. A ratio of 0.3 for basic to total nitrogen seems to be rather well established even for fairly narrow asphaltic fractions.

From the above discussions concerning sulfur, oxygen and nitrogen it is evident that a high percentage of the molecules in asphalt contain one or all of these elements. Truly, it is erroneous to call asphalt a collection of high molecular weight hydrocarbons.

Metals and Salts

Vanadium occurs in considerable amounts in certain native asphalts. The appearance of this element is almost universal in asphaltic materials and may be connected with the element's well known catalytic activity. Several careful studies have been made of the vanadium compounds in crude oils.

Skinner[10] found that vanadium existed in Santa Maria Valley (California) Crude Oil as a vanadium-porphyrin complex which concentrated largely in the asphaltic fraction of the crude. He found that these compounds were stable to heat and chemical action.

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Woodle and Chandler[11] concluded that vanadium exists in a crude oil as a family of compounds covering a broad range of molecular weight.

Dunning, Moore and Denekas[12] from studies of adsorption spectra, found evidence of considerable amounts of nickel porphyrin in petroleum extracts. Since uranium is frequently found associated with high carbon content material, it would not be surprising to find this element in asphaltic materials.

Crude petroleum always contains a certain amount of mineral matter. Some of this is present as oil-soluble compounds, but most is in a water solution dispersed in the oil. Since asphalt is manufactured from the residue from the distillation of crude oil, it contains concentrated amounts of the mineral matter and metal-organic compounds.

The ash content of asphalts varies from almost zero to a maximum of about 1 per cent. Desalting the crude oil reduces the mineral content of the asphalt. Analysis of petroleum ash shows a high content of silicate and sulfate combined with sodium, calcium, magnesium and iron. Much of the iron comes from contact with steel pipes, vessels, etc. Traces of many other metals are found.

Important Physical, Colloidal and Chemical Properties

In the use of asphalts, the properties of most practical importance are:

1. Rheological or flow,
2. Adhesion,
3. Durability.

These have been thought of as physical properties and usually are evaluated by physical tests often of an empirical nature. Only since it has been realized that asphalts are colloidal materials has real progress been made in a study of these important properties.

On the basis of colloidal classification asphalts generally fall into three general types.[2] These are:

1. Sol type,
2. Gel type,
3. Intermediate or sol-gel type.

With the sol asphalt, the high molecular weight compounds present are peptized until the system exhibits many of the properties of a true solution. With the gel asphalt, there is a scarcity of stabilizing agents with the result that the asphaltic micelles are poorly dispersed and tend to form bonds because of mutual attractions. The sol-gel type is intermediate between the other two types. Of course there are many degrees of gradation between the two extremes.

Thus, the colloidal properties of an asphalt are dependent upon its chemical composition. Differences in the chemistry of the oil fractions of the three types of asphalt are illustrated in the figure. In the triangular diagram is plotted the average percentage of aromatic carbon, CH_3 plus aliphatic CH_2 carbon, and other forms of carbon which probably consist largely of naphthenic rings. Although the points representing the three typical asphalts are closely grouped, it can be seen that the oil fraction from the gel asphalt is highest in CH_3 plus CH_2 while the oil from the sol asphalt is highest in aromatic carbon. The sol-gel asphalt is highest in other (naphthenic) carbon.

How Chemistry Influences Manufacture

After is has been determined what chemical properties are required for a particular use, these properties can be obtained by several methods. The first and probably the most fruitful method is selection of a suitable crude source. Many satisfactory asphalts are made by vacuum reduction of a crude oil.

Vacuum reduction results in a removal of the lower boiling point, lower molecular weight material. The higher the temperature and the lower the pressure, the higher the molecular weight of the distillate and the higher the average molecular weight of the residue (asphalt).

Precipitation with a hydrocarbon such as propane or extraction with a selective solvent such as furfural or phenol is sometimes used for producing asphalts. Although similar in some respects, the asphalt obtained by the action of solvents does not have the same properties as that of the asphalt obtained from the same crude by vacuum reduction. Vacuum distillation and solvent separation are both carried out primarily for the light oils obtained rather than for the asphalt produced.

Thermal cracking is another process which yields asphaltic material. Compared with straight run asphalts, cracked residua are high in aromatic content. Because of this high aromaticity, cracked asphalts do not mix well with other asphalts or with uncracked distillates. Cracked asphalts usually exhibit Newtonian flow and high susceptibility to temperature change, and are used for special purposes where these properties are required.

Air blowing is one method of changing the properties of asphalts. Asphaltic residua usually are blown with air at about 500F. The process is an exothermic one. Most of the oxygen from the air goes to CO_2 and water vapor in the off gas while some is taken up by the asphalt.

As mentioned previously, Knotnerus[8] found that the oxygen remaining in the asphalt can be accounted for by the formation of hydroxyl, carbonyl, acid and ester groups. The ester content accounts for about 60 percent of the oxygen taken up, and these groups are especially important because they link two molecules and thus form higher molecular weight material. At higher temperatures there are also carbon to carbon linkages developed during airblowing. Thus, the chemical composition and in turn the colloidal and physical characteristics of an asphalt can be changed somewhat by changing the temperature of airblowing.

Some flexibility in the airblowing process can be obtained by varying the consistency of the charge stock. An asphalt manufactured by airblowing a low viscosity residuum will have different properties than an asphalt made by airblowing the same residuum which has been vacuum reduced to a higher viscosity.

Summary

The many and varied uses for asphalt depend primarily upon its colloidal properties which determine such important properties as rheological characteristics, adhesion and durability. The colloidal properties in turn are determined by the chemistry of the asphalt. As more becomes known concerning the chemistry of asphalt it should be possible to define the composition required for a particular use. A better understanding of asphalt chemistry also will permit selection of the crude source and method of processing which will yield the type of chemical compounds required to give the properties resulting in best durability and service.

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★ ★ ★

Petreco Bender Sweetening Process

Licensed by: The Petrolite Corporation

DESCRIPTION: This process sweetens petroleum distillates, principally of middle range, by oxidation of mercaptans to disulfides in the presence of lead catalysts, in a fixed bed. Commercial units are processing streams such as diesel, kerosine, jet fuel, stove oil and gasoline of mercaptan sulfur from 0.004 to 0.1 wt. %. Streams of exceptionally high mercaptan content can be sweetened by recirculating a portion of the sweet product, thus lowering average mercaptan of the feed. Stream rates are from 1200 to 25,000 BPD, at operating temperatures of 90 to 140°F.

Charge stock is sent through the unit at uniform rate. Its temperature is established either from pilot plant study or experience. Based on mercaptan content, fixed quantities of sulfur, alkali and air are added to the distillate stream ahead of a mixing valve. The mixture flows up through the catalyst beds where mercaptans are converted to disulfides. Sweetened oil then flows to product storage.

H_2S must be removed from charge oil prior to processing in order to maintain proper balance of materials on the catalyst. Steam stripping is most commonly used for straight-run distillates. If steam stripping causes water content of the stream to reach 300 ppm or higher, filters or separators are recommended to prevent moisture damage to the catalyst. If H_2S is present, a simple caustic wash may be used; separation should be good enough to leave distillate relatively moisture-free.

CATALYST: The fixed catalyst bed consists of 1/8 to 1/4" porous stone pellets coated with lead salts. Size of the chambers depends on both feed rate and RSH content. Two, three and even four vessels piped in series are being used. However, recent performance data shows two vessels in series are adequate. Catalyst life is 17 months or longer.

CHEMICALS:

Sulfur: Lighter distillates — 1.0 to 1.25 theoretical equivalents
Middle distillates — 1.5 to 2.0 theoretical equivalents

Air: 0.2 to 1.5 SCF/Bbl of charge

Alkali: Generally less than 10 lb NaOH/M Bbl of charge

TREATING COSTS:
Chemicals, Cents/Bbl

Catalyst Maintenance	0.2-0.4
Sulfur	0.002 to 0.4
Alkali	0.005 to 0.04
Air	0.005 to 0.10

OPERATING MANPOWER: 1/8 to 1/4 man per shift.

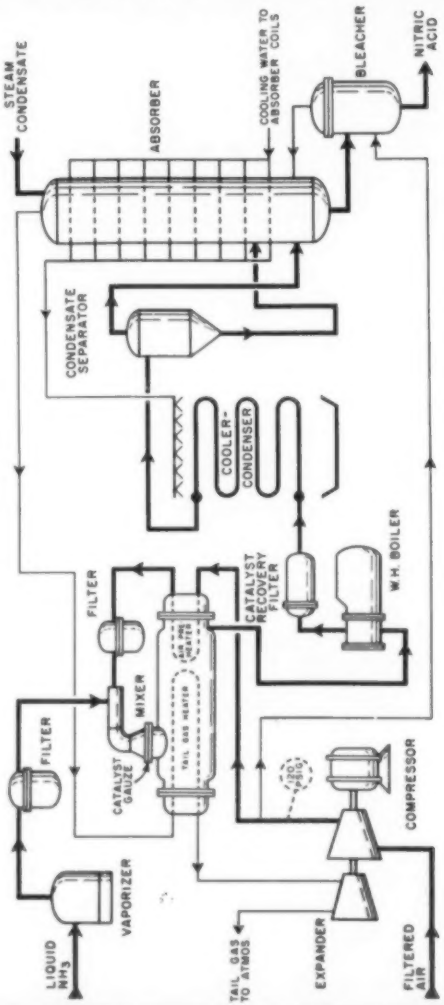
OPERATING DATA FROM EXISTING PLANTS

Type of Stream	Charge Rate BPD	RSH Cont. % By Wt.	Catalyst Towers, No. and Size	Air Req'd. Std. Ft.³/Bbl.	Sulfur Req'd. Theor. Equiv.	Caustic or PbO Sol. Req'd. #/MBbls.	Man Hrs. Daily for Oper'n	Treating & Catalyst Reworking Costs Cents/Bbl.	Install Est. Cost $/Bbl.	PbO Cont. Prod. Ppm	Oxy. Cont. Spent Air %	Treating Temp. °F.
Jet Fuel Kerosine	6,000 to 10,000	0.007 to 0.035	3-6'x20'	0.5	1.0 to 2.0	6 NaOH 0.8 PbO	4-3/4	No Rework. for 3 yrs. 0.5	20	2-4	—	130°
No. 1 Fuel Kerosine	4,500	0.007 to 0.01	3-6'x10'	1.0	1.6	10 NaOH 1.3 PbO	8	No Rework. for 3 yrs. 0.25	10	1-3	—	130° 140°
No. 1 Fuel Kerosine	4,500	0.007 to 0.01	4-3'-6"x10'	1.0	1.6	10 NaOH 1.3 PbO	8	No Rework. for 3 yrs. 0.20	10	1-3	—	130° 140°
Kerosine	7,600 to 14,000	0.007 to 0.01	4-6'x25'	0.05	1.7	5-7 NaOH 0.7 PbO	4	17 months Cat. life 0.70	15	4-6	0	130°
Kerosine	20,000 to 25,000	0.015 to 0.09	3-10'x24'	0.35 to 1.9	1.25 to 2.0	5-25 NaOH	4-8	No Rework. to Date 0.8	30	5-20	0-3.0	130°
P.D. Gasoline	1,200 Charge 3,600 Recycle	0.045 to 0.09	2-4'8"x18'	1.0 to 1.7	1.2 to 1.4	18 NaOH 0.5 PbO	8	No Rework. to date 0.65	16	—	0	85° 90°

Nitric Acid via Ammonia Oxidation

Licensed by: E. I. du Pont de Nemours & Co. (Inc.)

Data Provided by: The Fluor Corporation, Ltd.



Nitric Acid via Ammonia Oxidation

Licensed by: E. I. du Pont de Nemours & Co. (Inc.)

Data Provided by: The Fluor Corporation, Ltd.

DESCRIPTION: This process produces pure nitric acid of up to 65% by weight HNO_3. A mixture of ammonia vapor and clean pre-heated air, under pressure, passes through a platinum-rhodium gauze which catalyzes the oxidation of ammonia to nitric oxide (NO). Hot converter effluent resulting from the highly exothermic reaction is cooled in a series of heat recovery exchangers and finally in a cooler-condenser where some of the NO is oxidized to NO_2 and the latter absorbed in condensed water of reaction to form dilute nitric acid.

Gas and condensate then go to an internally cooled absorber where conversion of nitrogen oxides to nitric acid is completed. The concentrated acid leaving the absorber is finally stripped of dissolved NO_2 with air which also supplies the balance of the oxygen for the absorber reactions.

The heat recovery and air compressor drive scheme shown is only one of several possible combinations. Another, for example, heats the tail gas to such a temperature that expansion in a turbine provides the total compressor driving energy.

FEEDSTOCK:

Ammonia:	Purity	99.5%	Min
	N. V. M.	0.5%	Max
	Oil	5	ppm Max
	Chlorides	0.5	ppm Max

PRODUCT YIELDS: 91 - 94%, depending on cooling water temperature.

SERVICE FACTOR: 97 - 98%

UTILITIES: (for particular heat and power recovery system shown on flow diagram) per ton HNO_3:

Steam, net excess for export (50 psig)	600 Lbs.
Electricity	190 KWH
Cooling Water (85°)	35 M Gal.

CATALYST: Inventory, 4 - 6 troy oz. per daily ton capacity. Consumption, 0.006-0.01 troy oz. per ton HNO_3.

CHEMICALS:

NH_3	0.290 - 0.297 ton/ton HNO_3
Air	137 MSCF/ton HNO_3
Condensate	740 lbs/ton HNO_3

OPERATING PERSONNEL: 2 men/shift

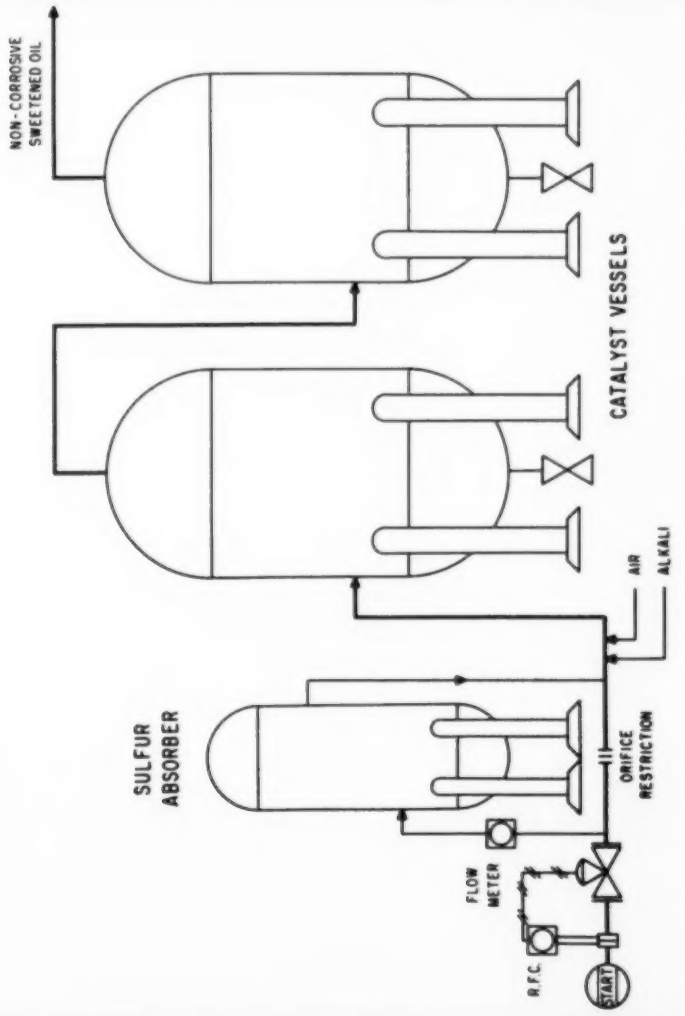
INVESTMENT: $7,000 - $10,000 per daily ton capacity in units 60 - 300 ton/day

MAINTENANCE:

Labor	5800 - 8800 man-hours/year
Materials and Supplies	1.5% of investment

Petreco Bender Sweetening Process

Licensed by: The Petrolite Corporation



Du Pont FOA-2 is added to residual fuel as it's pumped into sludge-ridden tank.

$20 worth of FOA-2 saved $800 desludging job ... and with no downtime

A power plant serving two industrial laboratories burns between 1,000 and 1,500 gallons of residual fuel, daily, from a 50,000-gallon tank.

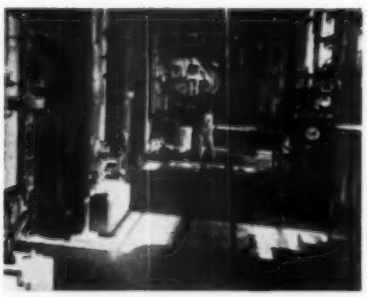
Recently, it was discovered that six inches of sludge had accumulated in the bottom of the tank. Constant temperature had to be maintained in the laboratories, so a tank-cleaning firm was called in. They gave a firm estimate of $800 for cleaning the tank mechanically. Considerable downtime would be required.

Looking for an alternative, the power superintendent decided to try using Du Pont Fuel Oil Additive No. 2 to break down the sludge. After one week of operation, during which only $20 worth of FOA-2 was used, no sludge could be detected. Moreover, there was no downtime. *The tank was in use all during the clean-up period.* Boiler room operations were completely trouble-free throughout the time the sludge was being dispersed and burned with the oil.

In addition to sludge removal, prevention of sludge is an improvement FOA-2 gives residual fuels. It is an excellent stabilizer, solubilizer, and dispersant.

Being nonmetallic, the additive burns with the fuel, leaving neither ash nor other residue. Refiners as well as their customers profit from the use of FOA-2, because it helps to stabilize all forms of distillate fuel oils, as well as residual fuel. These include blends such as catalytic-cracked stocks combined with straight-run products.

Your Du Pont representative can give you further details. Or write for a copy of our comprehensive 24-page FOA-2 book. It contains complete technical and experimental data. E. I. DU PONT DE NEMOURS & CO. (INC.), Petroleum Chemicals Division, Wilmington 98, Delaware.



This is the powerhouse that *had to* maintain service, so that essential temperature control, in the laboratories it served, could also be maintained.

See the "DU PONT SHOW OF THE MONTH" on CBS

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What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

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It's also designed for analytical correlative control . . .

New Process Control Computer

A SECOND aircraft and missiles industry-related company, Genesys Corporation . . . a new, wholly-owned subsidiary of Chance Vought Aircraft, Inc. . . . has entered the field of process control via digital computers. First was Thompson-Ramo-Wooldridge, who unveiled their RW-300 a little more than a year ago.

Genesys' major purpose is to concentrate on development of system nucleus products, according to engineering vice president Geoffrey Post. Typical of this is the dynamic memory processor, in the upper left hand corner of the company's prototype tower control computer illustrated here.

The memory processors are designed for two purposes: First, to serve as an analytical correlative control computer for test and evaluation phases, and second to serve as economic fixed-program control computers for optimizing basic processes. The analytical prototype unit is designed to give answers required for establishing a special-purpose control computer designed expressly for optimum control of the particular process. Or, the analytical prototype can be left at the unit for permanent use.

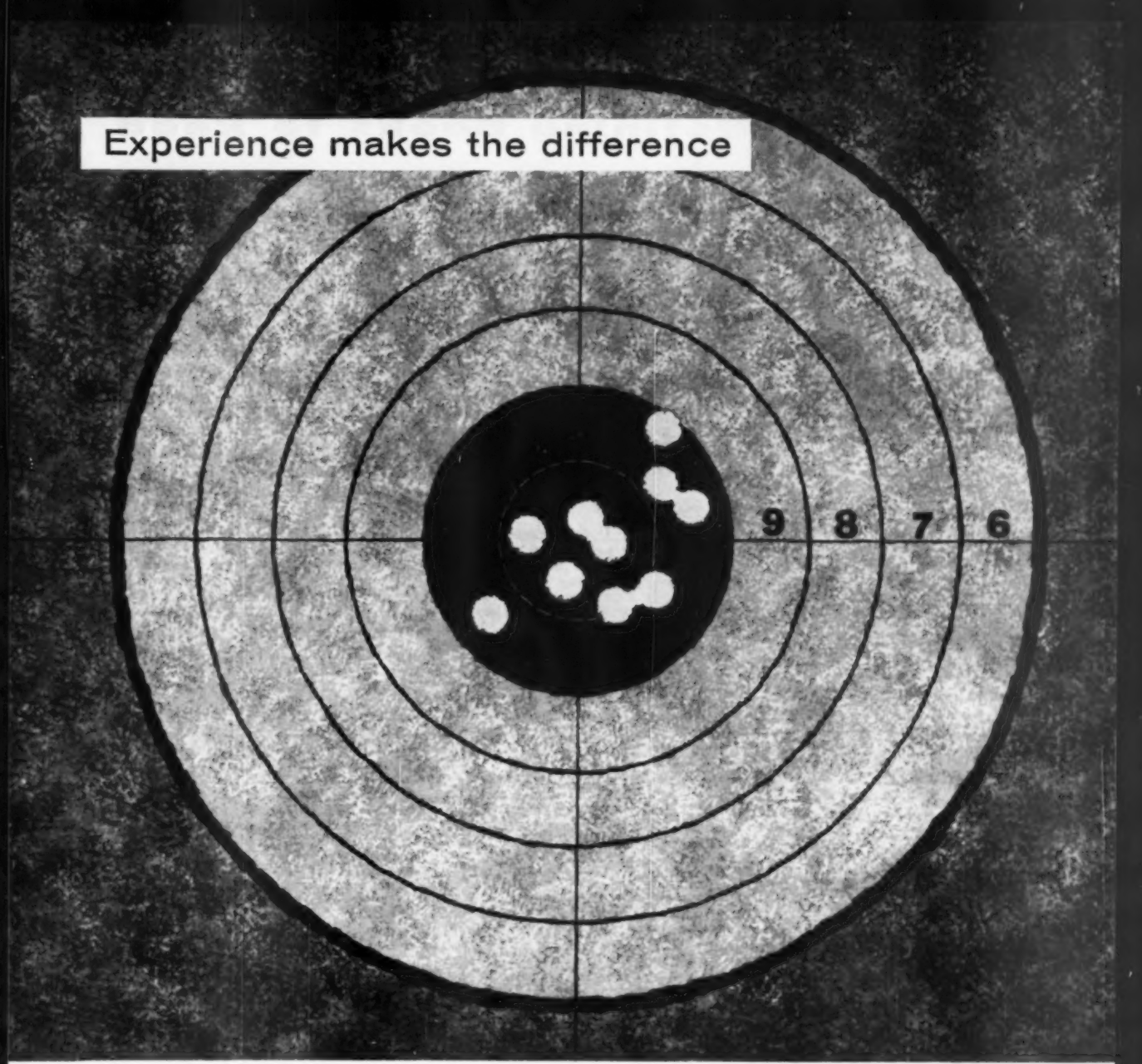
Composed of a digital memory processor, existing process instrumentation and input and output equipment, cost of the processor and input-output equipment can be below $100,000 and cost of the final control computer well below the prototype, Genesys claims.

Concept of the system is predicated on the observation that almost no complex system today is known by its exact dynamics and further that it is a rare simplified system where abstraction of mathematics truly defines system behavior. This is where the correlative computer comes in, says Genesys. Not necessarily a sophisticated device, it could be a simple decision-maker based on rule of thumb . . . but can make or break system performance.

The worst process dynamics can be at least crudely stabilized and controlled, as evidenced by many existing systems. Genesys further states that optimization can be achieved through correlative computing methods, without full knowledge of system dynamics. To do this, process control people in refining and petrochemicals plants provide data on the gross nature of the process's dynamics, so that the computer designer can deduce preliminary correlation critera.

This critera is in effect a learning logic . . . if system performance wanes, Genesys states, key parameters being monitored will inform the operator. These parameters can then be adjusted in predetermined manner for their "best" operation. "Probably negligible" optimization would be added by further sophistification of this scheme, Genesys concludes.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



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Refining Books to Read

Engineering Economy, *by Clarence E. Bullinger, published by McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 36, New York. Pages, 379. Price, $7.*

This book provides an understanding of the type of economic study which engineers in industry are called upon to make when considering the functional solution of engineering problems. It consists of three separate but related analyses: The economy analysis, the intangible analysis, and the financial analysis. Problems, tables and charts are used extensively to good advantage.

Plastic Sheet Forming, *by Robert L. Butzko, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22, New York. Pages, 185. Price, $4.50.*

This book surveys the numerous applications related to this new process. It explains over 14 different kinds of products used in sheet forming, material selection, equipment, molds, sheet decoration, and costs. It is a good book for the engineer, designer and manufacturing technician. References could have been used to supplement material.

Cavitation in Hydrodynamics, *published by Philosophical Library, Inc., 15 East 40th Street, New York 16, New York. Price, $15.*

Here in one book are the 22 papers which were presented at the 1955 symposium held in England and attended by 140 delegates from 15 countries. This volume of proceedings is a review of the basic problems in cavitation and of recent progress in research in studying them. It is divided into six sections. There are over 300 illustrations.

NFPA No. 59, Standard for LPG at Utility Gas Plants, *published by National Fire Protection Association, 60 Batterymarch St., Boston 10, Massachusetts. Pages, 40. Price, $0.50.*

Standard contains many new changes on location of containers, installation of storage containers and handling. It pertains to the design, construction, location, installation and operation of LPG systems at utility facilities.

American Standard Y10.4, Letter Symbols for Heat and Thermodynamics, *published by American Standards Association, 70 East 45th Street, New York 17, New York. Price, $1.50.*

The revision replaces earlier standard issued in 1943. Extension revision incorporates many significant changes and new viewpoints. Emphasis has been given so that accepted practice in fundamentals established by the chemist and physicist, as well as in all fields of engineering, is fully represented.

Automatic Control: Principles and Practice, *by Werner G. Holzbock, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22, New York. Pages, 258. Price, $7.50.*

This guide offers the practical results of scientific research on control systems in non-mathematical terms. It provides the layman and technician with principles and applications. The book is organized from the topical or descriptive approach rather than the mathematical. Numerous charts and drawings aid the reader greatly.

Polyamide Resins, *by Donald E. Floyd, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22, New York. Pages, 185. Price $4.50.*

The basic chemistry and raw materials of polyamide resins, methods for their manufacture and information on all important applications is contained in this book. Applications include fibers and filaments, coatings and films, moldings, extrusions, adhesives, inks, castings, and sealants. An effort is made to relate applications to resin structure by the use of many charts and illustrations. References are conveniently listed after each chapter.

Chemical Process Economics, by John *Happel, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York. Pages, 291. Price, $8.50.*

Here is a working tool to assist in applying technical information to the economic design and operation of chemical-process plants. A special feature of the book is the appendix devoted to "rules of thumb" for the practical design of chemical plants based on experience of many engineering firms.

ASTM Manual for Rating Motor Fuels and Research Methods, *published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Pages, 180. Prices, $5. and $6.75 (non-members).*

Appendices in this manual cover apparatus, reference materials, operation, maintenance, service requirements, and installation of knock test engines. Presented in a systematic way — by word and picture — is factual information and data about knock testing equipment. Pages for notes are conveniently located in the back of the manual.

Smoley's Four Combined Tables, *published by C. K. Smoley & Sons, Inc., 30 School Lane, Scarsdale, New York. Pages, 1176.*

This eleventh edition of Smoley's combined tables includes extension of tables of logarithms and squares by 1/64 in. from 16 in. to 60 in., improved and parallel arrangement of logarithms and squares from 100 to 300 ft by ⅛ in. and extension of areas and circumferences for diameters from 100 to 200. Thumb indexes make it easy to find various sections of the tables.

Technical Editing, *by B. H. Weil, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22, New York. Pages, 278. Price, $5.75.*

Basic concepts and operating practices of internal communications, journal editing, book publishing, and graphic arts presentation for all technical fields are included in this book. It deals with editing as a primary communications step and relates the documents of all technical areas to the main purpose of serving the potential reader.

NFPA No. 58, Standard for LPG, *published by National Fire Protection Association, 60 Batterymarch St., Boston 10, Massachusetts. Pages, 80. Price, $0.50.*

Book contains new provisions on the location and construction of containers, liquid level gaging devices, exhaust systems and other provisions pertaining to the design, construction and operation of LPG installations.

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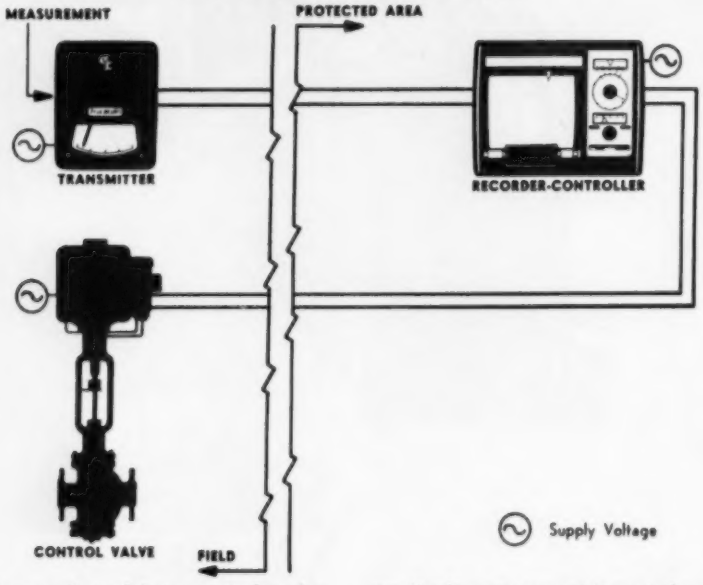


A new line of instruments for electronic control of process variables has been introduced by The Foxboro Company. "Electronic Consotrol Instrumentation" consists of advanced design transmitters, recorders, controllers, and valve operators, covering all functions in the control loop. Typical process measurements are converted at the transmitters to proportional current signals and instantaneously transmitted over unshielded lines to a control center. Outstanding features claimed, in addition to the use of magnetic amplifiers and transistors, are: Choice of motion balance or force balance transmitters; electrical measurement converters, entirely tubeless and mounted for front-of-panel accessibility; a new approach to control station design, and diversified installation arrangements using standard system components.

Announced in conjunction with the new line is a new concept in control panel design—a modified semi-graphic approach in which the process diagram is displayed at top-of-panel and instrumentation arranged in standard panel cut-outs below. One and two-pen electronic recorders with 4-in. strip charts are included.

Universal or simplified controller stations are available in two models. One has extra-wide mode adjustment ranges to handle any control applications, while the other is a simplified flow controller with adjustable proportional-plus-reset action. A choice of two transmitter types—force balance and motion balance—is offered. Either type can be used for field measurement and remote transmission of pressure, etc., to the central control panel. Further information is available from *The Foxboro Company*.

Circle number (41) on reply card.

New Nickel Catalyst

New reduced, stabilized nickel catalyst is non-pyrophoric so that it can be supplied without any type of protective medium. New catalyst is claimed to be safer and more easily handled than existing types, and is therefore expected to have broad applications in the slurry hydrogenation of organic compounds. *Chemical Products Division—Chemetron Corporation.*

Circle number (42) on reply card.

Portable Drawing Board

Weighing less than 8 ounces, this polystyrene precision drawing board comes with 2 transparent triangles (a 30/60 and 45) which clamp under board when not in use. The board has 2 retractable metal straight edges, eliminating the need for a T-square. Four recessed spring-clips hold a standard 8½ by 11 in. sheet of paper. *Leslie Creations.*

Circle number (43) on reply card.

Vapor Adsorption Device

A hydrocarbon adsorption unit that provides clean, dry air and gas is available in 14 standard sizes for both normal and high-pressure uses. It protects air and gas systems and pneumatically-operated instruments and mechanisms and utilizes the basic principles of capillary physics and surface chemistry for liquid-gas separation. *Selas Corporation of America.*

Circle number (44) on reply card.

Liquid Nitrogen Generator

New liquid nitrogen generator system automatically provides up to 95 liters daily of 99.5 percent pure liquid nitrogen. System is composed of nitrogen column, modified gas liquefier and 200-liter storage tank. *Arthur D. Little, Inc.*

Circle number (45) on reply card.

Prism-Grating Spectrophotometer

Instrument is said to be the first fully-automatic continuous scanning unit of the grating type. It offers high resolution, variable scanning speed, repetitive scanning, horizontal strip-chart recording with variable abscissa and ordinate expansions, convenient switching from double-beam to single-beam operation. *Beckman Instruments, Inc.*

Circle number (46) on reply card.

Computer Control Stations

Two new control stations for use with process computer systems are available. One receives a 3 to 15 psi pneumatic signal from the computer that is the value at which the measured variable should be maintained. Other station continuously records and indicates the controlled variable, records a related variable, and indicates valve top-pressure. *The Bristol Company.*

Circle number (47) on reply card.

Emergency Valve Actuator

A reverse acting, knob-controlled, panel-mounted manual valve for up to 200 psi pneumatic and hydraulic or vacuum service is especially suited for emergency control applications where a fast push-type action is more desirable than the standard pull-type. *Valvair Corporation.*

Circle number (48) on reply card.

All-Weather Vertical Motor

A new weather-protected vertical motor is intended for outdoor operation under all weather conditions—hurricane winds, driving rain, snow, sleet, and wind-blown sand. It is manufactured in rating from 250 to 2000 hp in both hollow and solid shaft construction. *The Louis Allis Co.*

Circle number (49) on reply card.

Tubine-Type Gas Meter

A series of turbine-type meters for gas flow measurement, with an accuracy of 0.5 percent of reading and 10 to 1 flow range spectrum from 0.03 to more than 30,000 cu ft per min at any pressure, is available. *The Pottermeter Company.*

Circle number (50) on reply card.

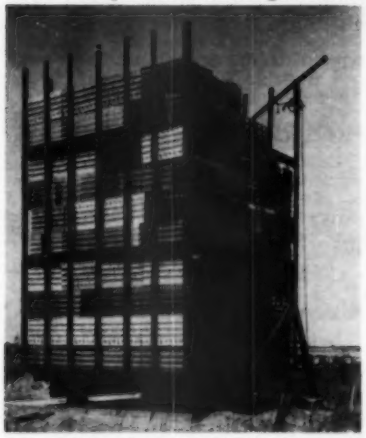
Nucleonic Liquid Level Controls

Measurement and control of liquid level in tanks is made easy by two new products: A level detector-controller and a continuous level measurement system. Both are mounted external to the vessel, have no contact with process materials, use no vacuum tubes. *Industrial Nucleonics Corporation.*

Circle number (51) on reply card.

Biological Waste Treatment Packing

A versatile plastic packing material, designed to improve conditions under which micro-organisms oxidize wastes has been developed for the biological treat-



ment of liquid wastes. Packing is made up of many layers of corrugated sheets of polystyrene or saran, depending on the type of chemical resistance needed. The material is assembled in self-supporting units and can be stacked as high as 42 ft with simple under-drains. *The Dow Chemical Company.*

Circle number (52) on reply card.

All-Glass Valves

New 2-in. and 1½-in. glass Y-type valves, made of borosilicate glass, are said to be impervious to corrosion. Valves are recommended for use in processing acidic metallic salts, various crystalline slurries and all acids, except hydrofluoric and hot, concentrated raw phosphoric acids, and can handle temperatures up to 250 F and line pressures to 50 psi. *Corning Glass Works.*

Circle number (53) on reply card.

New Level Controller

Compact, pneumatic-electronic control device detects and controls changes in media level. It is particularly valuable for application in vessels or small tanks which do not permit internal installations. System is obtainable with weather or explosion-proof housings. *Robertshaw-Fulton Controls Company.*

Circle number (54) on reply card.

Rate-of-Flow Controller

Unit will control flow rate of liquid with an accuracy of ¼ of 1 percent. Product is recommended for all liquid handling operations requiring the dispensing of a specific number of gallons per minute in a given period of time. A wide range of capacities can be controlled, ranging from ½ gal per min to 250 gal per min. *Bowser, Inc.*

Circle number (55) on reply card.

High Speed Telepulse System

Selective supervisory control system is designed for precise remote reading of process variables such as liquid levels, temperatures, pressures, etc. This 100 percent digital system also provides remote control of motors and valves and has an automatic error-check that makes it virtually immune to error. *Shand & Jurs Company.*

Circle number (56) on reply card.

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Quoth Sir Galva-Knight:

"CORROSION is a real dragon, that eateth up PROFITS!"

. . . And Nowery J. Smith Company hot-dip galvanizing is real corrosion protection for Gulf Coast industry! Any ferrous metal item, from a bolt to a beam, can be given an economical, long-lasting armor-plating of zinc in the Nowery J. Smith Company's hot-dip vats . . . the largest in the Southwest, operated by the South's largest commercial hot-dip galvanizers!

Nowery J. Smith COMPANY

one of the SMITH Industries

Commercial Galvanizing • Pickling • Oiling
Metallizing • Sandblasting • Prime Coating, and/or Painting

8000 Hempstead Hwy., P. O. Box 7398, UNderwood 9-1425, Houston 8, Texas

New Refining Literature

New Data Processing System

A new 4-page bulletin announces availability of a new data-processing system. System is a standard, 100-channel data logger featuring pinboard programming and all solid-state construction. It is designed for process plants, power plants, pilot operations, or wherever variables such as temperatures, pressures, flows, etc., are to be recorded. *Beckman Systems Division.*

Circle number (57) on reply card.

Packaged Compressor Plants

A 12-page brochure fully describes how these packaged compressor plants can be adaptable for any type of operation where gases must be compressed. Plant engineering to meet specific field conditions, problems presented by each installation and flexibility for anticipated future operation is also discussed in this brochure. *Stearns-Roger Mfg. Co.*

Circle number (58) on reply card.

Floor Grating & Stair Treads

A 16-page catalog on open floor grating and stair treads features product illustrations of rectangular grating with various wearing surfaces, abrasive embedded non-skid grating, U-type grating, radial grating, and numerous styles of treads. *Reliance Steel Products Company.*

Circle number (59) on reply card.

ONLY the application-engineered

D A T A G A G E*

REMOTE MEASUREMENT AND CONTROL SYSTEM

offers these exclusive advantages

NEW ACCURACY
- Only digital system with 1/16" accuracy independent of product gravity.
- Only system satisfactory for use in FLOATING ROOF TANKS.
- Only system to give reliable readings during blending turbulence.

NEW RELIABILITY
- Only system with POWER FLOAT (moving mechanical surface finder) which checks itself automatically.
- Transistors are used instead of short-lived vacuum tubes.
- A true digital system with unlimited-distance, error-safe telemetering.

NEW FLEXIBILITY
- Single dial control for both level and temperature measurement.
- 100 reading point capacity; applicable for alarm devices, valve and pump controls, remote transmission for data processing.
- Application-engineered approach gives you assured performance.

*Trademark registration applied for

Write for complete information, specify Bulletin M-601.

TEXAS INSTRUMENTS
INCORPORATED
INDUSTRIAL INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: HOULAB

Bauxite Specifications

Forty-four page bulletin fully describes product specifications, users' experience, manufacture and origins of activated bauxite and Fullers Earth. Applications are described for use in adsorption, desiccating, and are diluent. Several pages are also devoted to laboratory methods for testing the performance of the several types of bauxite and Fullers Earth products available. *Floridin Company.*

Circle number (60) on reply card.

Firebrick Data Card

Data card summarizes all of the technical data published previously concerning B&W Firebrick, is printed on card stock, and 3-hole punched for easy insertion in technical notebooks. *Babcock & Wilcox Company.*

Circle number (61) on reply card.

Kinematic Flowmeter Design

New technical bulletin discusses proposed method of evaluating design of kinematic flowmeters of the turbine or propeller type. Experimental results are correlated over a wide range of fluid conditions and geometric variations, and coefficients compared against those predicted from a one-dimensional design equation. *Fischer & Porter Company.*

Circle number (62) on reply card.

Multi-Thermocouple Assemblies

Engineering data bulletin contains details on various types of construction, information and specifications on components in thermocouple assembly, and data sheet for recording of specifications for a particular applications. *Thermo Electric Company, Inc.*

Circle number (63) on reply card.

Vacuum Melting Data Sheets

New data and specification sheets cover vacuum melting techniques and high-temperature vacuum-melted alloys. One of the new alloys is a precipitation-hardening nickel base alloy with high strength in the 600 to 1800 F range. It is said to be one of the strongest materials that can be formed or welded. *General Electric Company.*

Circle number (64) on reply card.

Temperature Detectors

New 36-page illustrated catalog gives complete information about new lines of resistance thermometers for temperatures up to 1000 F. Catalog provides a tubular listing of specifications by application and design and a list of accessory equipment. *Leeds & Northrup Company.*

Circle number (65) on reply card.

Just a few copies left . . .

Bright New Horizons for Asphalt Reprints of this RE special report, published in March, are still available . . . in a very limited quantity. Discussing outlook for demand, specifications, design of modern asphalt plants, and synthetic asphalts, copies of this 20-page reprint are available at 50 cents each. Send your order and coin or check to:

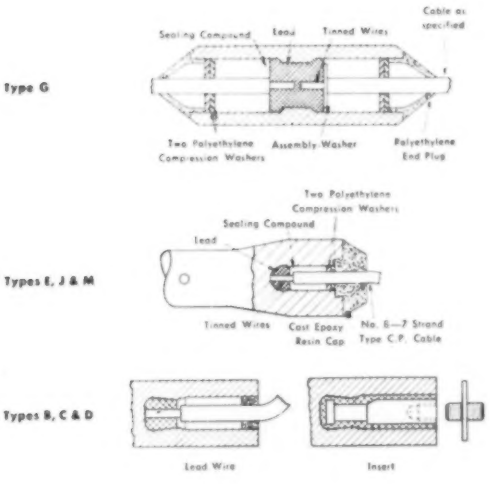
The Refining Engineer
Reader Service Department C
P. O. Box 1589
Dallas 21, Texas

the Pipeline Engineer

Oil..Gas
Products
Pipelining

DURIRON® IMPRESSED CURRENT ANODES

For more positive cathodic protection of all types of structures used throughout the petroleum industry, insist on DURIRON® ANODES. Duriron performs as well as graphite in all the easy services, and far outperforms graphite when the going gets tough in marshlands, at river crossings, or wherever it is impractical to use backfill. Duriron anodes have proven their superiority for the protection of pipelines, drilling rigs, well casings, storage tanks, and similar structures. For real protection, get Duriron.



STANDARD ANODE SIZES

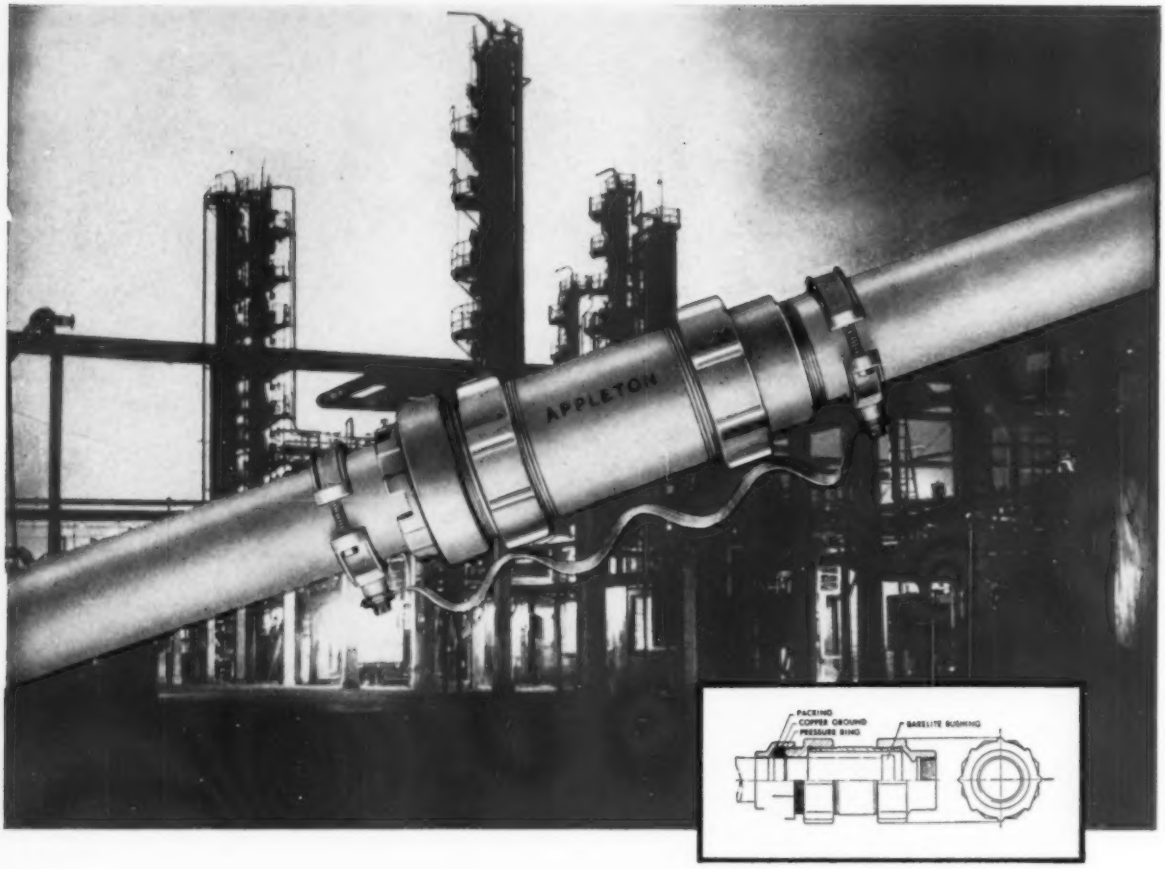
Type Anode	Size	Area Sq. Ft.	Weight (Lbs.)	General Application
B	1" x 60"	1.4	14	Fresh Water
C*	1½" x 60"	2.0	25	Ground Bed
D	2" x 60"	2.6	46	Ground Bed
E	3" x 60"	4.0	115	Salt Water
G	2" x 9"	0.4	5	Ducts
J	3" x 36"	2.5	80	Salt Water
M	2" x 60"	2.8	57	Salt Water

*Applicable also in fresh water service. Should not be used in ground beds without backfill.

THE DURIRON COMPANY, INC. / DAYTON, OHIO

DURCO

APPLETON® "XJ" Conduit Expansion Joints



Relieve the *strain* of expansion and contraction on long runs of rigid conduit

Temperature changes place a terrific strain on all long conduit runs. To relieve this potentially dangerous condition, it is best to install APPLETON "XJ" Expansion Joints at frequent intervals along the entire system. These weatherproof joints, for use with heavy-wall conduit, have a metallic packing and a bonding jumper to assure the entire conduit system remains a continuous electrical conductor. The jumper, installed in accordance with U. L. recommendations, gives double protection against extreme expansion movement reducing the effectiveness of the metallic bond.

As the conduit is inserted in the joint, a bushing is placed on the end in the manner shown. This bushing permits maximum conduit movement and yet the conduit can never pull free of the joint. The APPLETON "XJ" Conduit Expansion Joint features a metallic packing and pressure ring at the flexible end to keep the joint weatherproof at all times.

Wherever a long run conduit installation exists, the need for APPLETON "XJ" Expansion Joints exists. Interior or exterior, from Texas to Maine, temperature strains do exist, so take advantage of APPLETON'S product research program to give you the precision products you require . . . APPLETON "XJ" Weatherproof Expansion Joints for all long run conduit installations.

Sold Through Franchised Distributors Only

APPLETON ELECTRIC COMPANY
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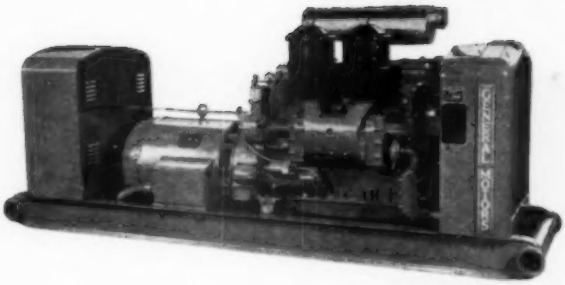

OPEN TYPE

CLOSED TYPE

From the world's most experienced producers of

ENGINE GENERATOR SETS

1500 Watts to 1000 Kilowatts

TRAILER MOUNTED

STEWART & STEVENSON

Stewart & Stevenson provides the most complete range of performance-proved engine generator sets. Combination Oil Field Utility Units, Rig Lighting Plants, A.C. Units, D.C. Units, heat exchanger cooled, radiator cooled, portable or stationary, explosion proof, standard type or custom built for any need.

Select the kind of power you prefer—Diesel, Natural Gas or LPG. Call, write or wire today for complete information on your engine generator set requirements.

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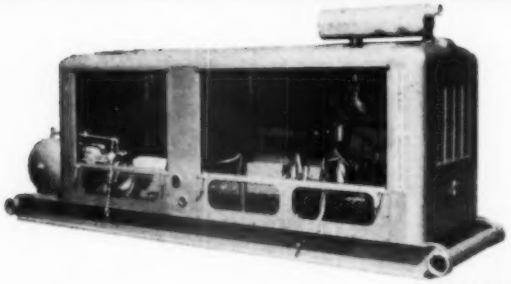
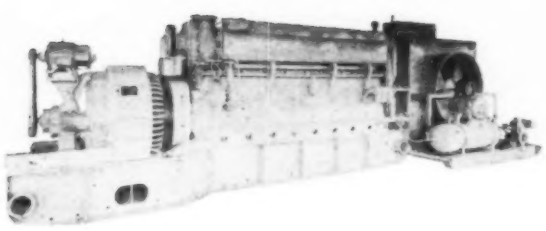
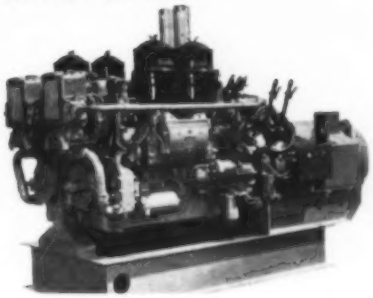


UTILITY UNIT

450 KW SKID MOUNTED



HEAT EXCHANGER TYPE



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ADVERTISED PRODUCTS, SEE READER SERVICE CARD

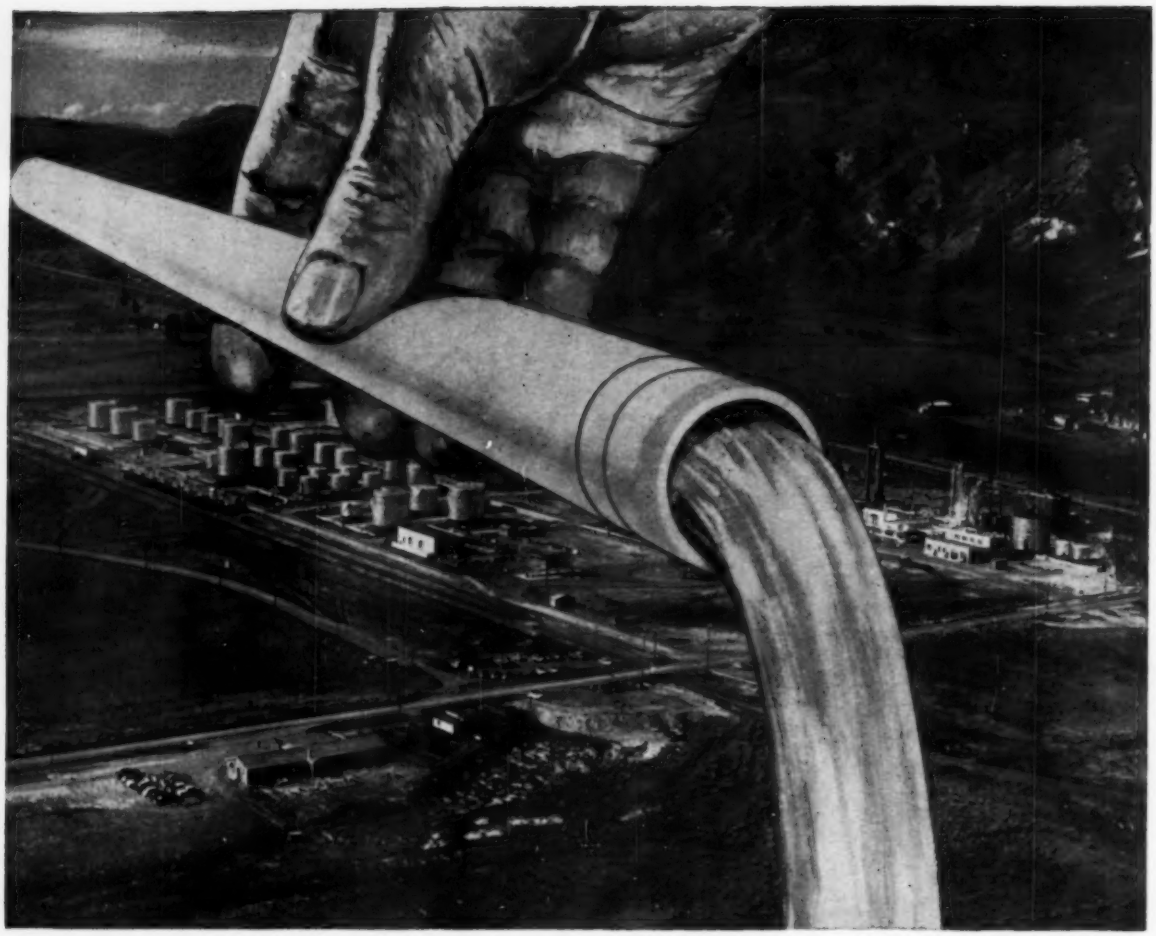
CP Trenchdrils and CP Compressors team up on the Trans-Canada Pipe Line project. It's rough, rugged country, running 40% to 50% rock.

CP PIPELINE TWINS... TOP TEAM FOR TOUGH SECTIONS

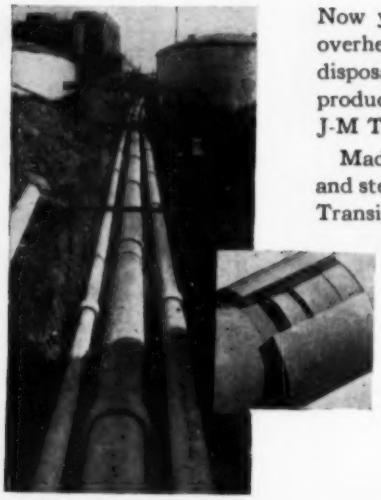
Use the dependable CP "Power Vane" 600 Rotary Compressor with the hard slugging GTD-400 Trenchdril for a ditching team that can't be topped—or stopped! CP "Power Vane" Rotary Compressors also available in capacities of 125, 210, 365, and 900 cfm. Get details. Call your nearby CP Distributor. Or write directly to *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N. Y.*

Chicago Pneumatic

PNEUMATIC TOOLS • AIR COMPRESSORS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS • AVIATION ACCESSORIES



Corrosion-resistant TRANSITE PIPE proved best for salt water disposal lines



Transite Pipe is made in a full range of sizes for salt water disposal, lead lines or fresh water supply lines.

Now you can reduce the tremendous overhead involved in replacing salt water disposal lines. Do what more and more producers are doing every year—install J-M Transite® Pressure Pipe.

Made of rugged asbestos and cement, and steam cured for added permanence, Transite is remarkably resistant to the corrosive action of salt water on the inside, soils on the outside. In fact, it has provided years of dependable service in many cases where other pipe materials have failed inside of a few months.

Transite offers many installation economies. It is light in weight and easy to handle. Most sizes can be unloaded and lowered into the trench without mechanical handling equipment. Its Ring-Tite® Coupling speeds assembly . . . provides tight yet flexible joints that permit deflection of pipe without special fittings.

For more information, see your Johns-Manville representative, or write for brochures TR-50A and TR-51A. Johns-Manville, Box 14, New York 16, New York. In Canada, 265 Lakeshore Road East, Port Credit, Ontario.

JOHNS-MANVILLE

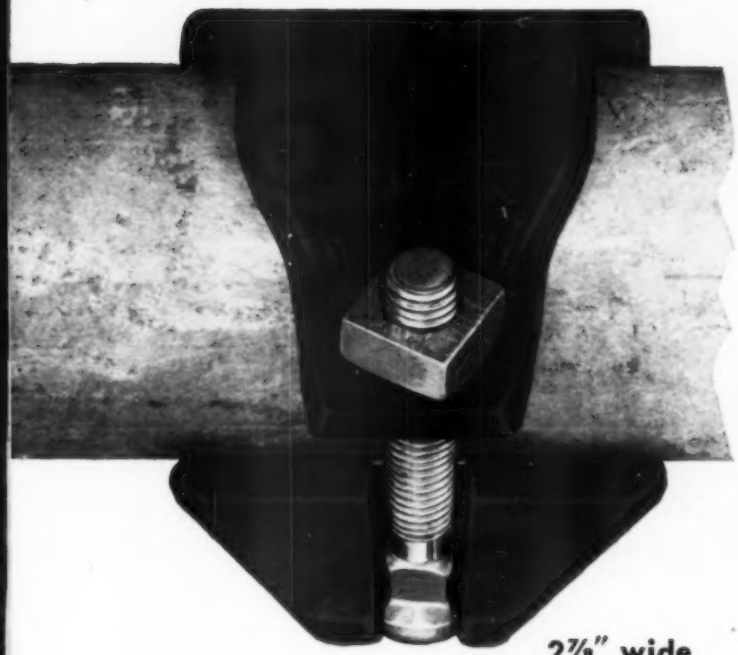
100 YEARS OF QUALITY PRODUCTS . . . 1858-1958

JOHNS-MANVILLE JM PRODUCTS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Now a JUNIOR EMERGENCY PIPE CLAMP

with big clamp permanence!



2⅞" wide
ACTUAL SIZE

A companion to the old reliable Emergency Pipe Clamp that has served industry for a half-century. The JUNIOR, a single bolt clamp, is 2⅞" wide. Undersells most band-type clamps.

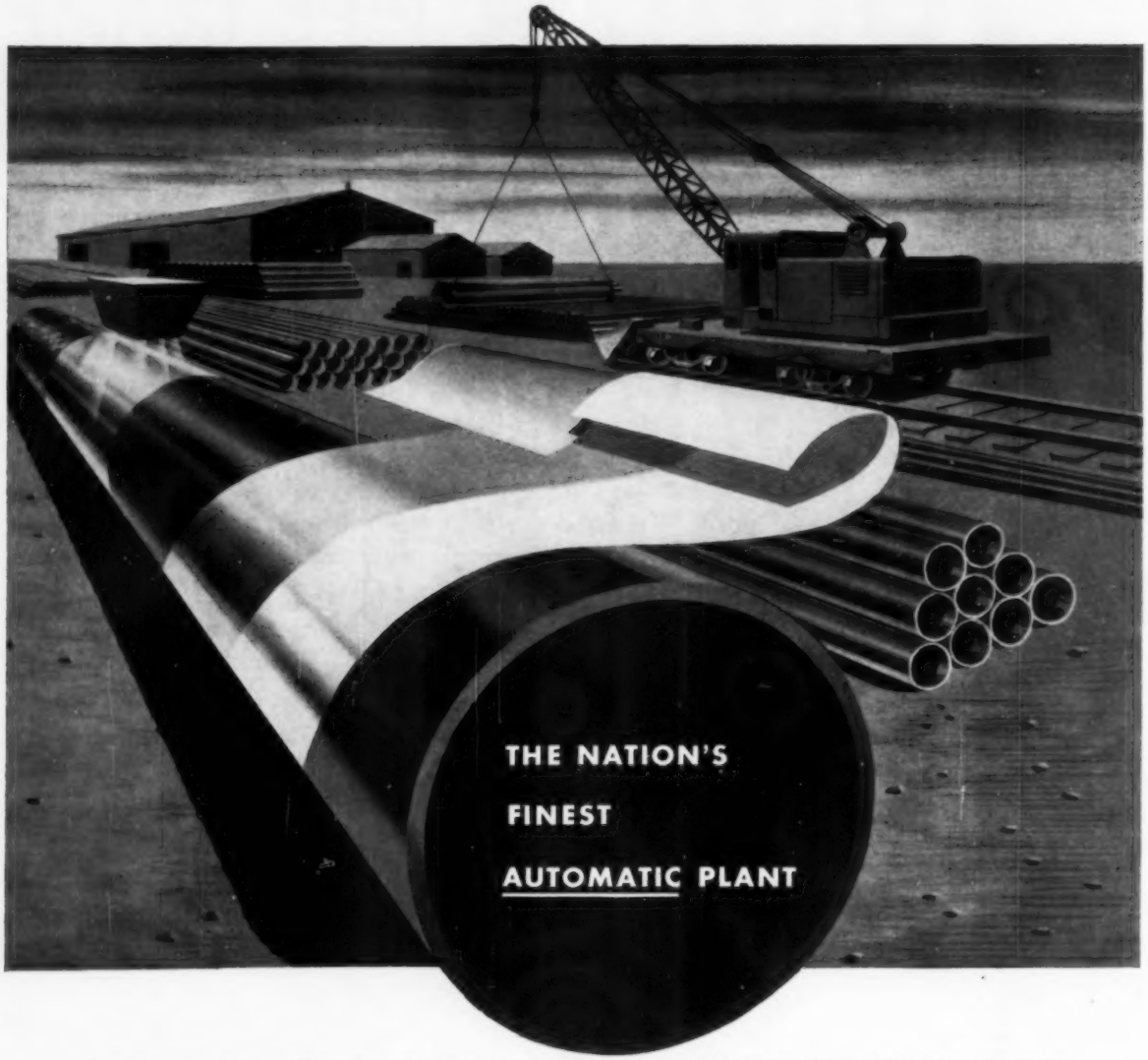
Made of malleable iron, it has a full-length hinge along one side, a single oversized, plated bolt. Lug on gasket half is slotted for quick application — without removing nut. The "recessed" pressure-equalizing gasket, covering entire wide half of clamp, is cemented in. A lasting installation.

Lug on gasket half is slotted

M. B. SKINNER CO., South Bend, Ind.

SKINNER-SEAL JUNIOR EMERGENCY PIPE CLAMP

Call Southern ... for the fastest service on the finest quality coated and wrapped pipe



Now in operation—and serving the Southeast—our new Southern Pipe Coating Company plant, offering the nation's finest *automatic* pipe coating and wrapping. Better service, exceptionally qualified personnel, strategic location (with in-transit privileges), new modern 17-acre facility—all make the Southern story so welcome to gas and gasoline transmission and distribution companies. A special emphasis is made on cleaning all pipe by modern grit blasting, which cleans the pipe more quickly and evenly, permitting a smooth, even coating of primer, enamel and wrapping. We can also store your bare pipe in our yard, if you require, and our truck fleet can deliver anywhere in the South. We will give immediate shipment to the job site—on time—with the exact pipe you need, coated and wrapped to your specifications. Try Southern—for quality, dependability, service.

For illustrated catalog and specifications chart, or for a quotation, call or write

Southern Pipe Coating Company

795 PEACHTREE STREET, N. E. ATLANTA 8, GEORGIA

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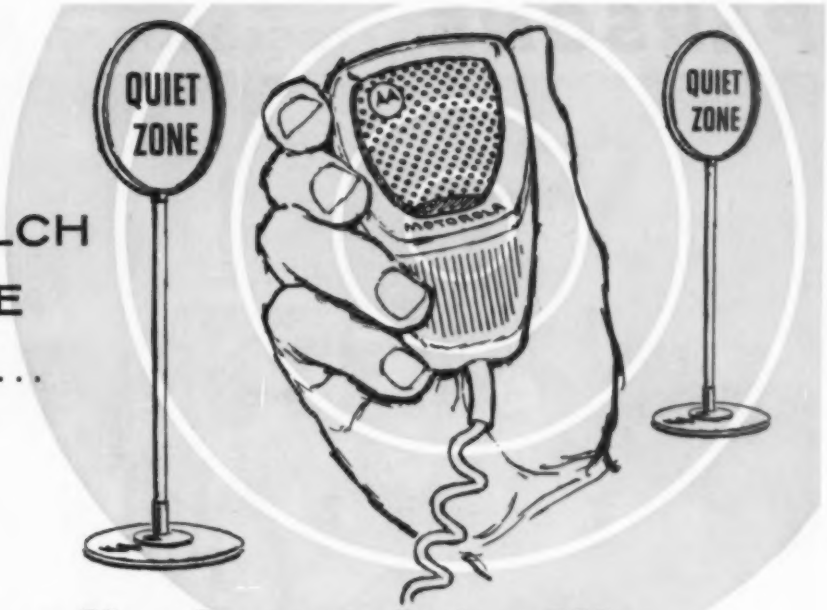
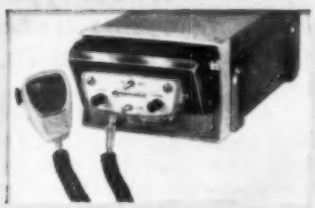
NEW
MOTOROLA
DUAL-SQUELCH
PRIVATE-LINE
2-WAY RADIO...



silences all channel traffic except your own messages



POWER

PRIVATE-LINE radiophone is now available in T-POWER (shown above), which features a completely transistorized power supply, as well as TWIN-V radio with 6/12 volt operation.

Get the complete facts about this startling new type of 2-way radio. Write today for these 2 new folders on PRIVATE-LINE radiophone.

Now, with the new Dual-Squelch PRIVATE-LINE radio, you get all the benefits of improved PRIVATE-LINE operation . . . *plus* easy integration for mixed fleets and monitor-before-transmit.

Because PRIVATE-LINE radio is quiet except when receiving a call from another radio in your own system, you eliminate all the "channel chatter." It's much like having the frequency all to yourself. You benefit by reducing the number of missed or misunderstood messages . . . operator fatigue is reduced . . . overall efficiency is increased.

Dual-Squelch PRIVATE-LINE radio gives you these basic features . . . and more. Now you can make a gradual changeover to PRIVATE-LINE operation. During the transition period, your messages can be received by both Motorola conventional and PRIVATE-LINE radios. No longer is it necessary to make the complete changeover to PRIVATE-LINE operation at the same time. And with the new Dual-Squelch operation, you can have manual selection or optional automatic monitoring of the channel before transmitting.

Before you select your 2-way radio, you'll want to investigate Motorola Dual-Squelch PRIVATE-LINE radio.

MOTOROLA PRIVATE-LINE RADIOPHONE

MOTOROLA Communications & Electronics, Inc., A Subsidiary of Motorola, Inc., 4501 Augusta Boulevard, Chicago 51, Illinois

PARSONS® Trenchliners® for pipeliners

Need a good, small, ladder-type trencher? Then meet the Parsons 77. It's just 3 ft.-8 in. wide — and 5 ft.-8 in. "low". Weighs only 6700 lbs. Small in size but big in capacity, the 77 digs up to 21 lineal ft. of trench per minute, 6 to 18 in. wide, at depths to 5 ft. Big Parsons line offers you a complete selection of heavy-duty ladder and wheel-type machines for opening any size trench — from 6 inches to 6 feet wide — and up to 19 feet deep.

Mail to: PARSONS COMPANY, Newton, Iowa

Send us literature on: ☐ 150 ☐ 77 Trenchliner

NAME _____

TITLE _____

COMPANY _____

DIVISION _____

STREET _____

CITY, STATE _____

P818 PE

Wheel-type 150 opens trench 16 to 26 in. wide

There is no need to dig and backfill excess yardages on feeder lines, laterals, gathering systems, etc. This medium-size wheel-type Trenchliner fills the bill on secondary lines — and has ample work range to handle a good share of your main-line trenching, too. You get cutting widths from 16 to 26 inches, depths to 5¾ feet with the Parsons 150. What's more, 30 digging speeds from 12 inches to 25 lineal feet per minute assure maximum production at every depth, width, in all soil conditions. A hydraulic ram on vertical mast raises and lowers the digging wheel — gives infinite depth selections, maintains close grade tolerance even in toughest digging. A separate hydraulic ram tilts the mast, balances weight of wheel forward when traveling or trailer loading.

Heavy-duty wheel takes cast-steel buckets with self-sharpening, reversible "Tap-In" teeth, or quick-change gumbo buckets. Shiftable, reversible belt conveyor discharges spoil on either side. 16-inch crawlers, grouser-type shoes, provide plenty of digging traction for cross-country work. See Parsons distributor, or write for 150 literature.

PARSONS COMPANY

NEWTON, IOWA

A DIVISION OF KOEHRING COMPANY

How to save 20% in joining a pipe line

Line-up and welding costs can take a big part of your pipe line construction dollars. But here is how Armco Welded Steel Pipe can reduce these costs by as much as 20 per cent.

Armco Pipe is supplied in standard 50-foot lengths instead of the ordinary 40-foot or double-random lengths. This means at least 20 per cent fewer field joints. Line up and welding time is reduced and you have fewer sections to handle.

What's more, the wide range of diameters (6 to 36 inches) and wall thicknesses ($\frac{9}{64}$- to $\frac{1}{2}$-inch) available in Armco Pipe lets you make the most economical choice to meet your specific requirements.

Use Armco Welded Steel Pipe to meet requirements in the Natural Gasoline and Natural Gas Divisions and wherever else you need dependable line pipe. Mail coupon below for prices and delivery time. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 3968 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. Export: The Armco International Corporation.

Armco Drainage & Metal Products, Inc.
3968 Curtis Street, Middletown, Ohio

Send me prices and delivery time on Armco Line Pipe. I am interested in the following: diameter_____

wall thickness_____ quantity_____

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Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

ARMCO®

Armco Welded Steel Pipe

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Built Clean And Tough-- To Keep Your Spreads On Schedule

The Same Goes for Parts

When replacement parts are made to original equipment specifications, it follows naturally that they are made just as durable as the machine itself. That's why it will pay you to specify BUCYRUS-ERIE when parts are needed for your hoe. The know-how and experience of the men building Bucyrus-Eries every day just cannot be duplicated by "will fit experts" anywhere.

Bucyrus-Eries are built clean, tough and simple . . . are easy to service and maintain even when you're miles from a full service crew!

Bucyrus-Erie pipeline hoes are "Hi-Walkers" because they're equipped with tractor type crawlers. They give you plenty of clearance for working over roughest ground. Deep grousers take hold, keep your machine moving in muck and on slopes. Sealed bearings keep sand and dirt out of track rollers to cut maintenance.

Long, cambered booms give the operator plenty of reach . . . let him dig in closer, trenching or trimming. Big clutches run smooth, automatically adjust themselves for temperature changes.

On spreads all over the country, Bucyrus-Erie "Hi-Walkers" set the pace that keeps pipeliners ahead of schedule. See your nearby distributor today and find out more about the ½-yd. 15-B and the ¾-yd. 22-B. 531E58

A Familiar Sign... BUCYRUS ERIE *. . at Scenes of Progress*

BUCYRUS-ERIE COMPANY • SOUTH MILWAUKEE, WISCONSIN

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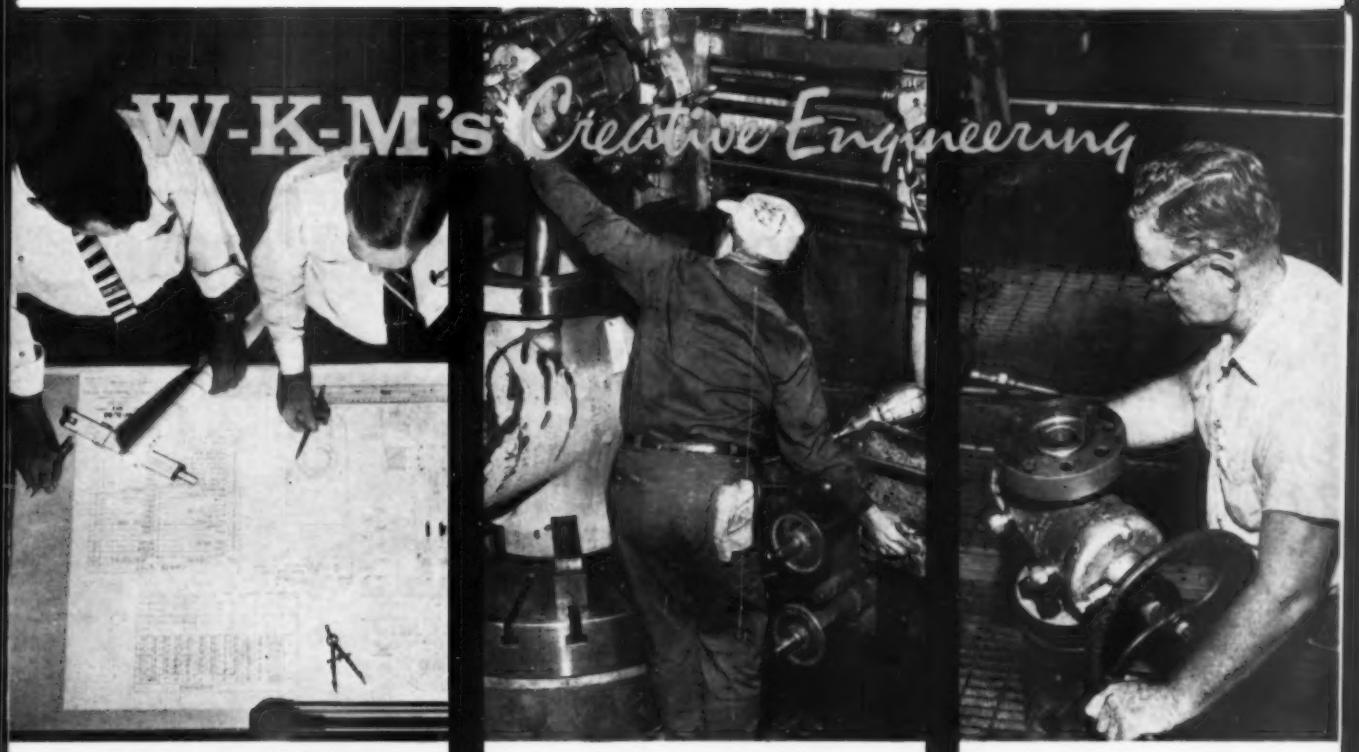
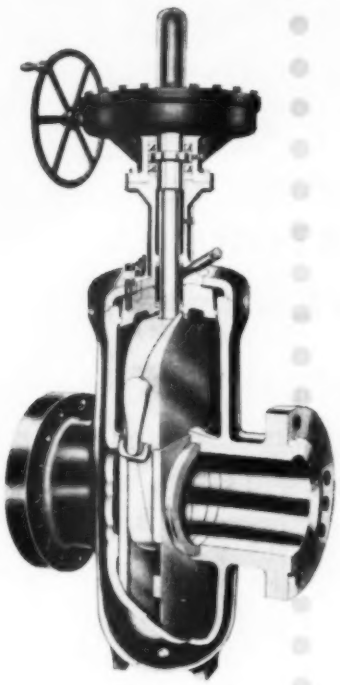


provides the design | the production | the testing

that assure dependable performance



W-K-M ASA Gate Valves

W-K-M's creative engineering is a continuous process that begins with a study of pipeliners' valve problems. It proceeds to design . . . extends through production . . . reaches a climax with the most rigorous testing procedures in the business: Every W-K-M valve passes tests that go far beyond the requirements of your operations.

W-K-M ASA Gate Valves are the best you can use in pipeline service. No other valves compete in design or quality of production.

For performance you can depend on, specify W-K-M when you requisition valves.

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS
Export Office: 45 ROCKEFELLER PLAZA, NEW YORK, N. Y.

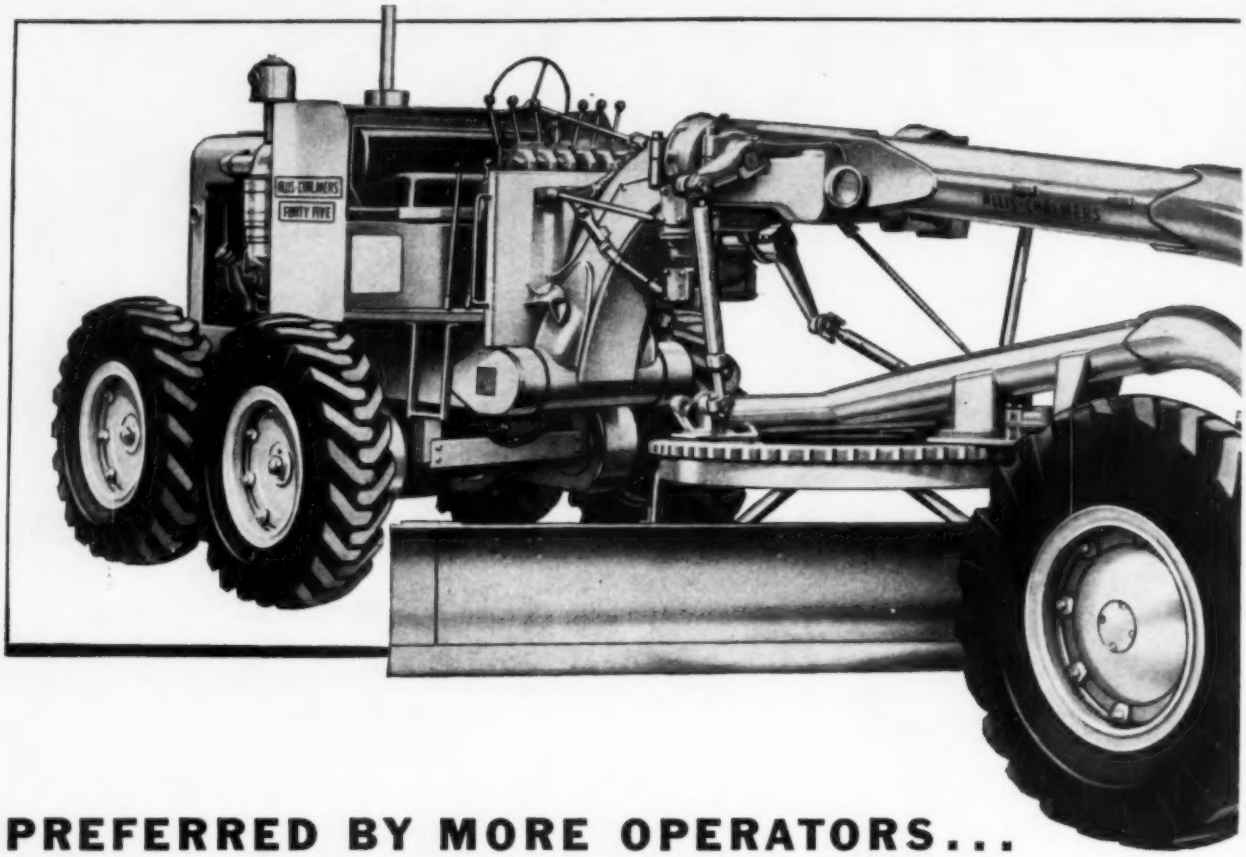
Features include: Parallel expanding gates • Through-conduit • Exclusive gate centralizer • Replaceable seats • Pressure seal bonnet • Lubricated seats • Two thrust roller bearings • Super-finished stems.

Design assures: No-surge operation • No turbulence • No pressure drop • Free passage of pigs or scrapers • Easy operation • "On-the-line" overhaul.

Write for Catalog 300

5818

For consistently tough jobs, compare with any other heavy-duty motor grader



PREFERRED BY MORE OPERATORS... BOUGHT BY MORE USERS EVERY DAY

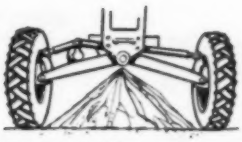
The FORTY FIVE has the power, weight, traction and speeds you need for high-production grading. Superior stability and precision control give you deep precision cuts or smooth finishes. The FORTY FIVE is built to take the shocks and strains of heavy-duty service — and to keep production steady. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

Look ahead... *move ahead* ...and stay ahead with **ALLIS-CHALMERS**

Allis-Chalmers FORTY FIVE performance

- 120 brake hp
- 6 forward speeds to 20.6 mph
- 3 reverse speeds to 7.0 mph
- 23,800 lb approx.

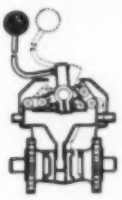
Advantages that mean more production . . . less maintenance . . . easier and better operation



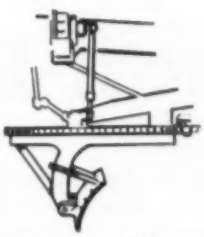
Extra high axle and throat clearance means bigger loads at the blade.

The ROLL-AWAY moldboard rolls dirt, gives more performance per horsepower, more production per gallon.

Fully enclosed power steering — easy control under all conditions.



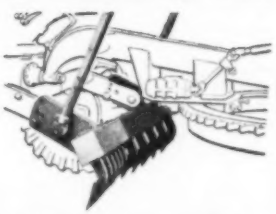
Toggle-type controls are exclusive with Allis-Chalmers.



Front-mounted lift cases eliminate long shafts that twist under loads.

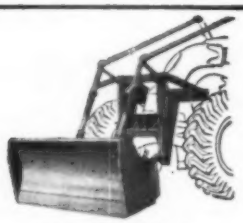
Matched attachments and accessories make it a year-round producer

All-steel, stand-up cab

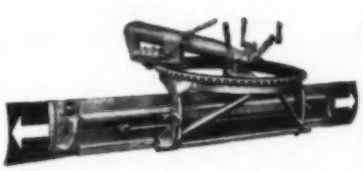


11-tooth, V-type scarifier

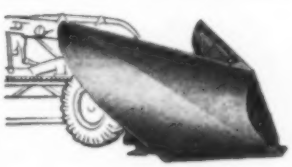
Hancock elevator



8-foot bulldozer



Hydraulic, shiftable moldboard

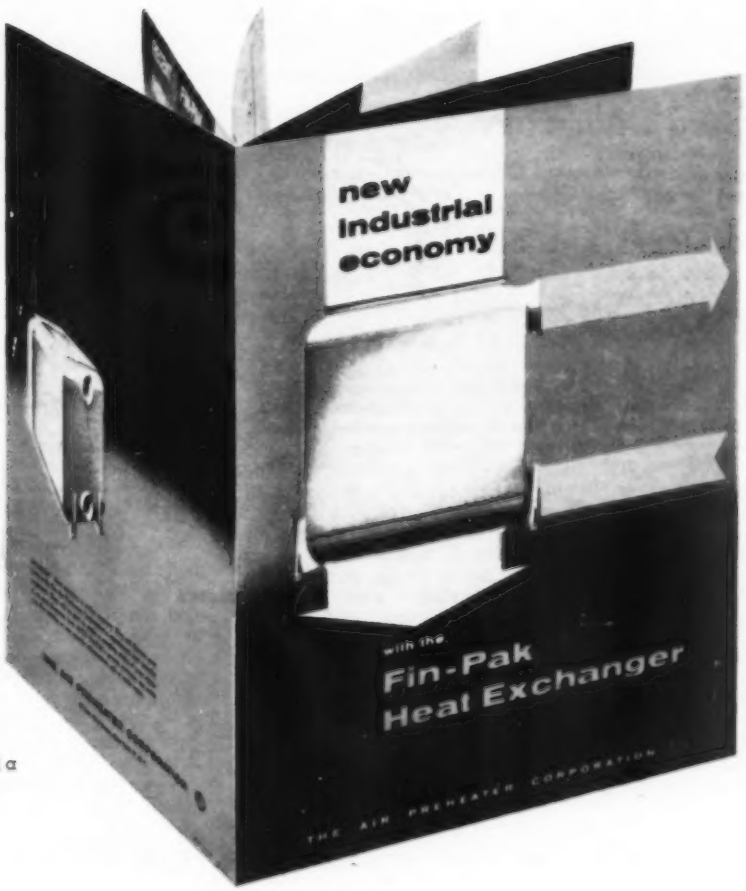


V-type snowplow

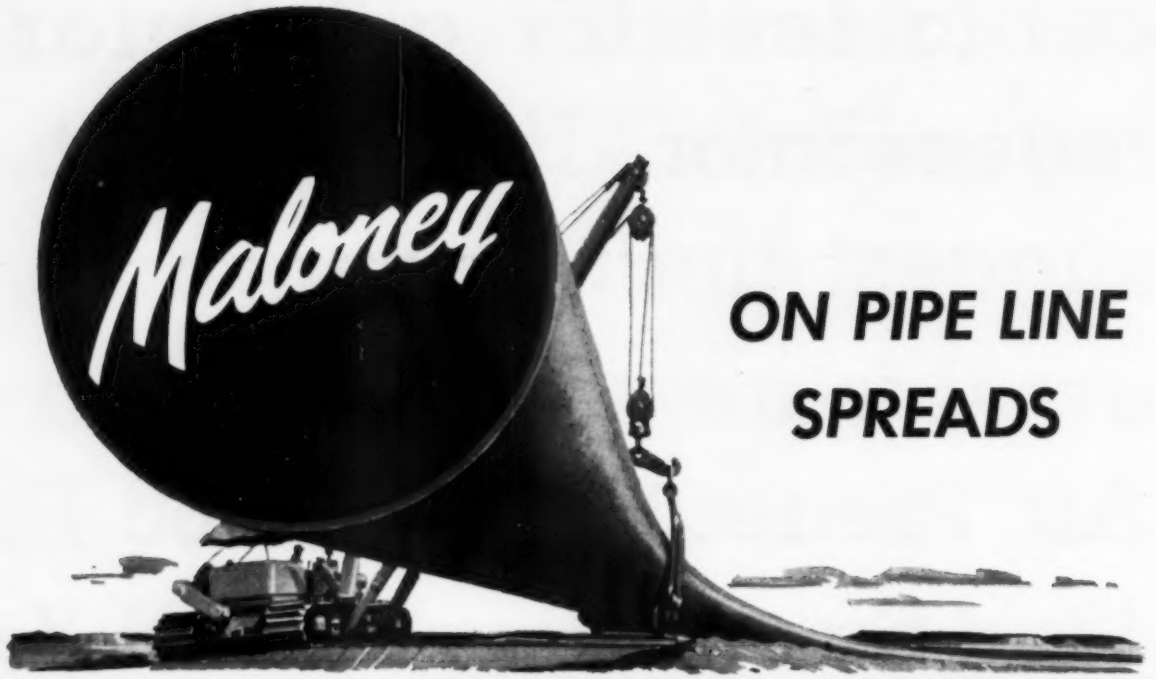
ROLL-AWAY is an Allis-Chalmers trademark.

Even when it's being installed, an APCO Fin-Pak heat exchanger starts to save you money. That's because less than 500 man-hours are necessary to complete the job (for a 5,000 hp gas turbine). Then the Fin-Pak proceeds to cut fuel expense as much as 32%*. Maintenance is nil. It even saves space—400 cubic feet in one installation instead of 1,050

cubic feet for a tubular regenerator. If these facts suggest finding out more, get this new booklet from: Air Preheater Corp., 60 E. 42nd Street, New York, N.Y.



*At 1500 F, a 6-1 pressure ratio, and a designed effectiveness of 75%.



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Minimum Practical Housing of Low Cost Compressor Stations

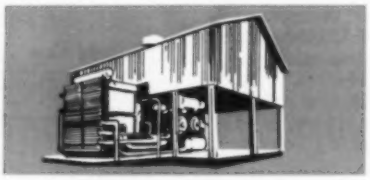
B. J. Thompson, *Warren Petroleum Corporation, Tulsa, Oklahoma*

With the rapid increase in remotely located, unattended compressor stations, the installation and operating costs of the units are receiving more attention. The manner in which a compressor station is weatherproofed can have a significant bearing on its continuity of operation, cost of operation, maintenance and salvage value.

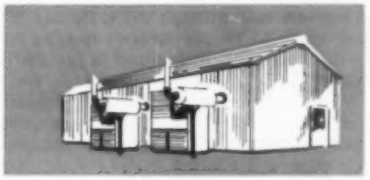
Why this discussion? A savings in investment of 1 to 3 percent can be effected by leaving the station unhoused.

In mild climates, stations of this kind are commonly installed without any housing whatever, yet it should be pointed out that the factors listed below should be carefully considered before making a decision to operate a station in the open air. Compressor facilities in severe climate locations have need for, and are usually provided with complete buildings.

Open or unhoused



Partially housed



Housed

What's Involved

These three factors should be considered in deciding on the station housing (or lack of it):

1. Climate — temperatures, rainfall, snow, dust and winds.
2. Expected duration of the operation at one location.
3. What is the extent of the financing allowed for the project. On the face of it, it would seem that if sufficient funds are available, and a short payout is not essential, then by all means include a complete building for all station machinery. But this reasoning is not always valid. There is, for instance, the problem of heat; open-air or partial housing may be **best.**

Unhoused Stations

General conditions attending *unhoused* stations may be:

1. Mild climate.
2. Moderate to low rainfall.
3. Short period location.
4. Extreme limit on installation cost.
5. General heat dissipation by radiation is desirable.

Some operators of open (unhoused) units practice part or all of the following protective suggestions:

1. Cover magnetos and coils with metal or plastic.
2. Cover spark plugs with metal protector made of sheet metal, oil can, other.
3. Spray coat ignition wires with silicone or other protective material (small individual pressure cans of silicone paint are available).
4. Compressors with open distance piece may have the rod and packing protected from dust by banding the openings with gasketed sheet metal.
5. The jacket water system may utilize a stable antifreeze with a low pour point.

Some operators believe that long range maintenance is less for housed units. Certainly overhauls and maintenance would usually be facilitated in a building in severe weather.

On the other hand, open air takes care of heat dissipation and minimizes the chances of explosions from gas leaks.

Conditions Indicating Partial to Complete Housing:

1. Severe climate, including temperatures, snow, dust, etc.
2. Overhead structure for trolley support.
3. Enclosure for tools and equipment.
4. General appearance.
5. Precedent.
6. Liberal investment funds.
7. Keep unauthorized people clear of the machinery.

If the climate is severe; maintenance, sound operation and appearance of the equipment may enhance a building. Each operating group should develop its own basis for determining the potential savings in costs if housing is provided. **Some remote operations of two to three years duration have seemed to require essentially equal maintenance for housed and unhoused units.**

Most stations have use for overhead trolley or crane during overhaul. A building structure strong enough to support the trolley adds materially to the efficiency and convenience of maintenance. However, portable "A" frames, mobile crane, etc., make good alternates.

It is convenient to store an optimum number of tools and equipment at each station which may be used in normal operating and repair functions. Storage inside a building is desirable for this type of equipment.

In addition to other features, the building can serve to keep unauthorized persons clear of the main machinery and automatic shutdown devices.

Conclusions

Compressor facilities can be installed and operated successfully without any housing. The location will generally determine whether or not housing is required. Installations located in mild climate are commonly unhoused. Those in severe climates have need for, and are usually provided with complete buildings. To date records are insufficient to determine whether or not long range maintenance costs for unhoused units will be any greater than for housed units.

All papers included in this installment of Graphic Engineering Digests were presented before American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Denver, Colorado, September 21-24, 1958.

How to Calculate Pipe Stress in Offshore Construction

Noah Roads, *Engineer, Tennessee Gas Transmission Company, Houston*

The 1957 expansion program of Tennessee Gas Transmission Company included an offshore gathering system of 12 in. to 26 in. pipe to be laid in water from 10 to 60 ft deep. The pipe was to be weight coated with concrete aggregate to provide negative buoyancy and a degree of corrosion protection. The studies here were made to evaluate laying methods and to arrive at practical specifications for guiding offshore construction forces.

Conclusion. Although the stiffening effect of concrete coating tends to reduce stresses in pipe being laid offshore, the reduction is negligible and is ignored in these calculations. Other factors not considered in the calculations are (1) Wave and current forces, (2) Possible adhesion of silt or sea life to pipe, (3) Tension or compression in pipe, (4) The fact that buoyant force is not continuous and (5) Tolerances on pipe and coating.

These forces seem to balance out except in rough weather.

However after construction started it was discovered that loading conditions on the barge and differences in coating thickness produced a shorter radii than those calculated. There was cracking of the concrete coating and in some cases the safe stresses were exceeded in the pipe. The radii of the curvature were increased to the following:

PIPE SIZE	RADIUS
26 in.	2343 ft
20 in.	1786 ft
16 in.	1385 ft
12 in.	1124 ft

Pipe Handling and Damage from Construction

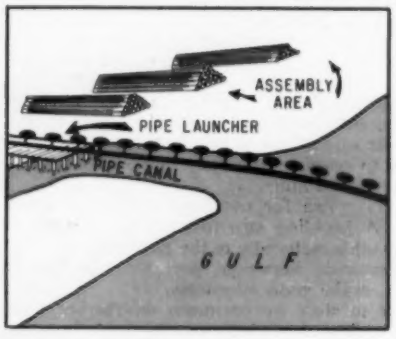
Construction damage can be summed up as one or a combination of these three conditions:

1. Buckling or weakening of carrier pipe,
2. Concrete coating falling off due to excessive bending,
3. Excessive cracking of the concrete coating.

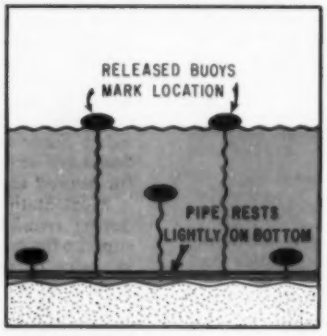
In all the examples checked, the third condition would occur first, so if laying procedures prevented excessive cracking of concrete, other types of construction damage would be eliminated.

For the purpose of discussion, the construction proposals received by Tennessee Gas called for three general types of pipe handling in the offshore laying. They were: 1. Negative buoyancy, 2. Point support, 3. Launching shoe.

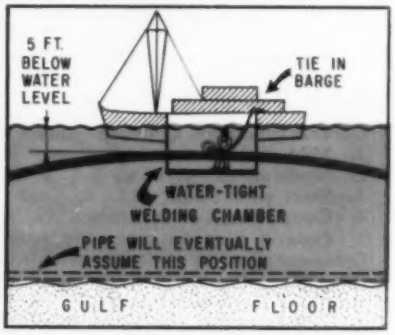
NEGATIVE BUOYANCY METHOD



Pipe sections assembled on land, buoys attached, launched into canal for towing into Gulf to laying site.



On entering Gulf, enough buoys released to give pipe negative buoyancy; pipe is then towed to final resting place.

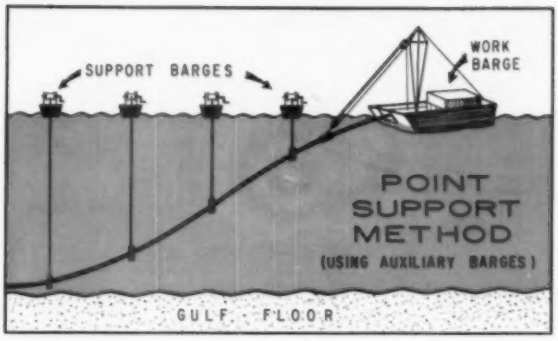


Ends of pipe are lifted to tie-in barge; ends are aligned and welded level; pipe is then again lowered to bottom. Welds are made 5 ft below water level in chamber that is pumped dry.

Negative Buoyancy Method

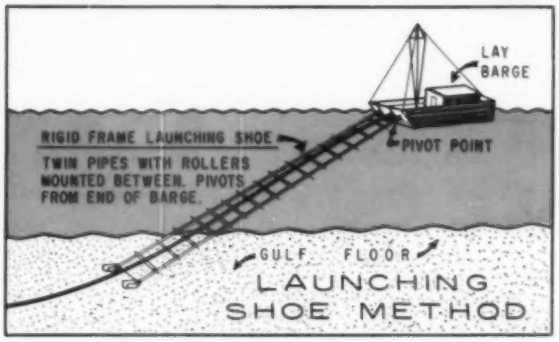
One contractor proposed that the pipe be assembled in sections on land with buoys attached, then launched into a specially dredged pipe canal; from here it would be floated to the edge of the Gulf. At this point sufficient pontoons would be released to give the pipe a slight negative buoyancy; then, resting lightly on the bottom, it would be towed to its final position. Later the various sections would be picked up for tie-in welds. The critical stresses of this method are developed in raising the pipe to surface, aligning the ends for welding and lowering back to bottom.

Other contractors suggested that pontoons be attached to the pipe as it was stovepiped from a lay barge — the pontoons to be removed after the pipe reached a position on bottom. The same stress calculations will apply as in the tie-in operation above.



Point Support Method

If at some time in a construction process, the pipe is supported by derricks, auxiliary barges or large, widely-spaced pontoons, the point support analysis given below will apply.


LAY BARGE
RIGID FRAME LAUNCHING SHOE
TWIN PIPES WITH ROLLERS MOUNTED BETWEEN PIVOTS FROM END OF BARGE.
PIVOT POINT
GULF FLOOR
LAUNCHING SHOE METHOD

Launching Shoe Method

The launching shoe is a long frame or ladder of two line pipes with rollers in between that support and guide the pipe to bottom. The buoyancy can be controlled by the amount of water admitted to the shoe. If the buoyancy of the shoe is the same as the weight of the pipe, the shoe will become approximately straight and the lower end of the pipe will act as if it were freely supported.

Theory of Stresses in Bending

For our purposes bending moment is considered the only source of pipe injury. These following relationships hold for elastic members in bending. So far as moment, radius of curvature and stress are concerned:

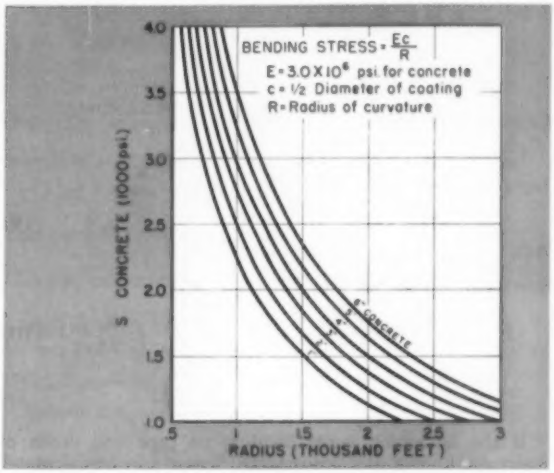
$$M = \frac{SI}{c} = \frac{EI}{R} \quad . \quad . \quad (1) \qquad \text{From this: } S = \frac{Ec}{R} \quad . \quad . \quad (2)$$

These equations give us a method of comparing the stress on concrete coating; from them, stress vs radius of curvature can be plotted for pipe of various size diameter. An example is shown in the accompanying chart.

Experience has shown that an indicated stress of 2500 psi on concrete is about maximum for safety. This being so, the following radii of curvature appear to be the minimum allowable:

26 in.	1700 ft	20 in.	1400 ft
16 in.	1000 ft	12 in.	750 ft

These radii of curvature produce a stress in steel of about 20,000 psi. Tennessee Gas engineers consider this a safe working stress. Now let's analyze the forces on pipe that will determine bending moment.



Minimum allowable radius to which 16-in. concrete coated pipe may be bent.

Bending Moment Analysis—Negative Buoyancy

This conforms closely to a beam with uniform loading fixed on the upper end and infinite in length, the lower end resting on a level surface. At the point of rest the moment and slope become zero.

The general moment equation of a uniformly loaded beam is:

$$M = M_a + V_{ab}x - \frac{wx^2}{2} \qquad \text{But } M_a = O$$

Therefore

$$M = V_{ab}x - \frac{wx^2}{2} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Explanation of Symbols Used

- M Moment — in. lb
- M_a Moment at point pipe touches bottom — O
- M_b Moment at point of last support — in. lb
- M_c Moment at center of sag portions of pipe — in. lb
- M_{fa} Fixed end moment at A if both ends are fixed
- M_{fb} Fixed end moment at B if both ends are fixed
- L Unsupported length of pipe — in.
- x Horizontal distance from origin — in.
- y Vertical distance from origin — in.
- y_b Height of support above bottom — in.
- θ Angular deflection from horizontal — radians
- θ_b Angle of pipe at last support — radians
- E Modulus of elasticity — psi = 30×10^6 for steel
- I Moment of inertia of pipe — in.^{4}
- R Radius of curvature — in.
- S Maximum bending stress in section — psi
- C Constant of integration
- w Net load on pipe — lb/in.
- Z Section modulus — in.^{3}
- c Distance from neutral axis of section to outer fibers — in.
- V_{ab} Shear at A in direction at B — lb

Integrating 3. $EI\theta = \frac{V_{ab}x^2}{2} - \frac{wx^3}{6} + C_1$ . . . . (4)

At $x = 0$, $\theta = 0$; Therefore $C_1 = 0$

At $x = L$, $\theta = \theta_b$; Therefore $EI\theta_b = \frac{V_{ab}L^2}{2} - \frac{wL^3}{6}$

Solving for V_{ab}: $V_{ab} = \frac{2EI\theta_b}{L^2} + \frac{wL}{3}$ . . . . (5)

V_{ab} is also the reaction at the bottom

Combining 3 and 5,

$$M = \frac{2EI\theta_b x}{L^2} + \frac{wLx}{3} - \frac{wx^2}{2} \quad . \quad . \quad . \quad (6)$$

Solving for $M = M_b$ at $x = L$

$$M_b = \frac{2EI\theta_b}{L} + \frac{wL^2}{3} - \frac{wL^2}{2} = \frac{2EI\theta_b}{L} - \frac{wL^2}{6} \quad . \quad . \quad (7)$$

Combining 4 and 5, $EI\theta = \frac{EI\theta_b x^2}{L^2} + \frac{wLx^2}{6} - \frac{wx^3}{6}$. (8)

Integrating Eq. 8, $EIy = \frac{EI\theta_b x^3}{3L^2} + \frac{wLx^3}{18} - \frac{wx^4}{24} + C_2$

. . . . . (9)

At $x = 0$, $y = 0$ Therefore $C_2 = 0$

Solve Eq. 9 at $x = vL$, $y = y_b$:

$$EIy_b = \frac{EI\theta_b L}{3} + \frac{wL^4}{18} - \frac{wL^4}{24} = \frac{EI\theta_b L}{3} + \frac{wL^4}{72} \quad . \quad (10)$$

$$\left(\text{or } y_b = \frac{\theta_b L}{3} + \frac{wL^4}{72EI}\right)$$

If the launching angle, loading on pipe and depth of water are known, the unsupported length can be calculated from Equation 10. This unsupported length can be substituted in Equation 7 to determine moment at the top. From Equation 1 the stress and Radius of Curvature can be calculated for comparison with safe values.

Solve (10) for w

$$\frac{wL^4}{72EI} = y_b - \frac{\theta_b L}{3} \text{ or } \left(w = \frac{72EIy_b}{L^4} - \frac{24EI\theta_b}{L^3}\right) \quad . \quad . \quad (11)$$

The value of Radius of Curvature is given by $M = \frac{EI}{R}$

Combining (1) and (7) and (11) M_b can be shown to be less than zero:

$$M_b = \frac{-EI}{R} = \frac{2EI\theta_b}{L} - \frac{L^2}{6}\left(\frac{72EIy_b}{L^4} - \frac{24EI\theta_b}{L^3}\right)$$

$$\therefore \frac{-EI}{R} = \frac{2EI\theta_b}{L} - \frac{12EIy_b}{L^2} + \frac{4EI\theta_b}{L}$$

Multiply (12) by $\frac{RL^2}{EI}$ $\therefore -L^2 = 6R\theta_b L - 12Ry_b$. (12)

Regroup terms and complete the squares then take square root of both sides $(L + 3R\theta_b) = (12Ry_b + 9R^2\theta_b^2)^{1/2}$

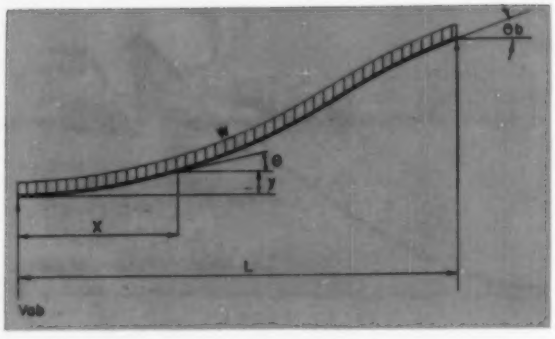
$$L = (12Ry_b + 9R^2{}_b^2)^{1/2} - 3R\theta_b \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

If radius of curvature, launching angle and depth of water are specified, Equation 13 can be used to find the unsupported length. Then Equation 11 will give the loading to make the pipe conform to this shape.

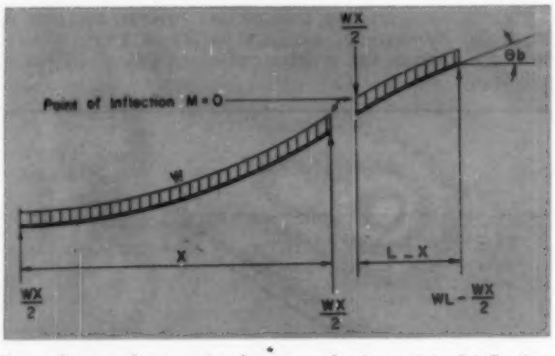
So far, only the moment at the upper end has been considered, this may not be the maximum moment.

The point of inflection can be determined (using Equation 6) by setting $M = 0$

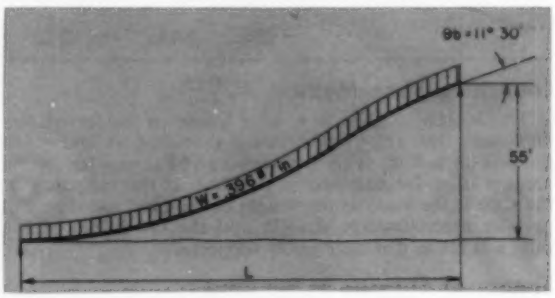
$$M = \frac{2EI\theta_b x}{L^2} + \frac{wLx}{3} - \frac{wx^2}{2} = \frac{2EI\theta_b}{L^2} + \frac{wL}{3} - \frac{wx}{2} = 0$$



Force diagram for negative buoyancy method.



Force diagram for negative buoyancy showing point of inflection.



Example of negative buoyancy method.

Solving for x $\therefore$ $\frac{wx}{2} = \frac{2EI\theta_b}{L^2} + \frac{wL}{3}$; $x = \frac{4EI\theta_b}{wL^2} + \frac{2L}{3}$

. . . . . (14)

Then

$$L - x = \frac{L}{3} - \frac{4EI\theta_b}{L^2} = \frac{-2}{wL}\left(\frac{3EI\theta_b}{L} - \frac{wL}{6}\right); \; L - x = \frac{-2M_b}{wL}$$

. . . . . (15)

The pipe can be considered as two separate portions: The sag as a simply supported beam, and the overbend as a cantilever with a load on the end and a uniform load.

The maximum moment of the sag portion $= \frac{wx^2}{8} = M_s$

. . . . . (16)

The maximum moment of the overbend is

$$\frac{-wx}{2}(L - x) - \frac{w(L-x)^2}{2} = M_b \quad . \quad . \quad . \quad (17)$$

If both moments are equal, but opposite in sign

$$\frac{wx^2}{8} = \frac{wLx}{2} - \frac{wx^2}{2} + \frac{wL^2}{2} - wLx - \frac{wx^2}{2}$$

From this it can be found that $x = 2(\sqrt{2}-1)L$

$$L - x = (3 - 2\sqrt{2})\ L = (3 - \sqrt{8})\ L = .17157L \quad . \quad (18)$$

Therefore, if $\frac{2M_b}{wL^2}$ is less than $(3-\sqrt{8})$, the maximum moment is in the sag.

This moment can be calculated from Equation 17.

Another useful formula derived from the same conclusions is the depth that the pipe can be lifted with certain negative buoyancy.

$$Y = \frac{3EI}{wR^2} \text{ Using same units as before.} \quad . \quad . \quad . \quad (19)$$

Other Methods

For the launching shoe method the same formulas give good approximations, but the moment of inertia would be for the entire structure.

In the point support method and the launching shoe method, the pipe has to be considered as a statically indeterminate structure.

In proposals using the point support method, the loading diagrams were integrated graphically to determine if they were approximately accurate. The equations for checking or designing of this method are:

$$M_a = M_{fa} - \frac{2EI}{L}\left(2\theta_a + \theta_b - \frac{3y_b}{L}\right). \quad . \quad (20)$$

$$M_b = M_{fb} - \frac{2EI}{L}\left(2\theta_a + \theta_b - \frac{3y_b}{L}\right). \quad . \quad (21)$$

These equations are developed from Equation 3:

$$M = M_a + V_{ab}x - \frac{wx^2}{2}$$

These equations can be used for the whole pipe or between any two supports.

In the study particular interest was given the negative buoyancy method. This method was the one with the most proposals. The launching shoe method was felt to be most practical. Analysis of the launching shoe method following reasoning for negative buoyancy seemed to give good results.

Example:

Consider, for example, laying 12.750-in. OD by .344-in. wall pipe, weight in salt water 43.63 lb/ft with 1770-lb buoys spaced on 43.3 ft centers. Depth of water is 55 ft. Launching angle is 11 deg 30 min. Design is for a minimum radius of 1124 ft.

The known values are:

$E = 30 \times 10^6$ psi.

$I = 258$ in.^{4}

$w = \frac{45.63}{12} - \frac{1770}{43.3} = .396$ lb/in.

$\theta_b = .2007$ Radians

$Y_b = 660$ in.

Use Equation 10

$$Y = \frac{\theta_b L}{3} + \frac{wL^4}{72EI}$$

Assume $L = 3000$-in. in $\frac{\theta_b L}{3}$ and calculate L in other term

gives $L^4 = 646.36 \times 10^{12}$

$L = 5042$-in.

Therefore, L is between 3000-in. and 5042-in.

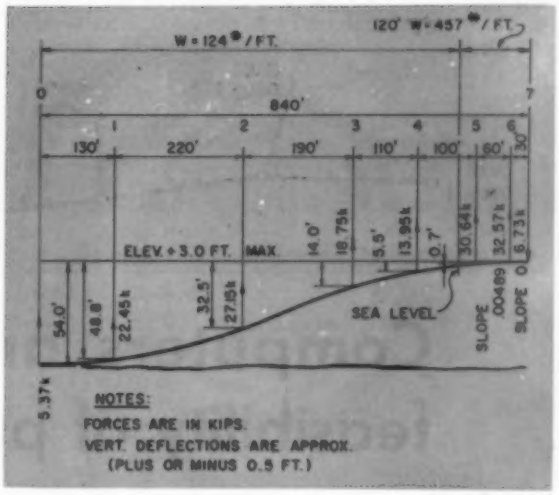
Assume $L = 4700$ in first term.

Other term gives $L^4 = 486.31$

$L = 4696$ in.

Calculate moment from Equation 7.

$$M = \frac{2EI\theta_b}{L} - \frac{wL^2}{6}$$



Example of point support method.

This gives $M = 7.94 \times 10^5$ lb

Using Equation (1) $M = \frac{EI}{R}$, we get $R = 9750$ in. $= 812.5$ ft

This analysis indicated that buoy spacing is too wide. So correct buoy spacing is calculated as follows:

Using Equation 13, $L = (12\,Ry_b + 9R^2\theta^2)^{1/2} - 3R\theta$

Substituting known values, then $L = 5034$ in.

Using Equation 11, w is $= \frac{72EIy_b}{L^4} - \frac{24EI\theta_b}{L^3}$

Substituting known values

$w = .281$ lb/in. $= 3.37$ lb/ft

Buoy spacing should be 41.9 ft.

Figure above shows an example using point support method for laying 26-in. OD by .500-in. wall pipe in 50 ft of water, designed for minimum radius of 2040 ft. The supports were buoys with ballast chambers.

In checking this proposal, the moments were calculated from the free end and moment diagram plotted. As stated earlier, this diagram was integrated graphically (with planimeter) to determine angular deflection. The angular deflection diagram was integrated graphically to determine linear deflection.

The moment at "O" would be nearly zero, because the pipe is essentially straight on the bottom to the left. The area of the moment diagram is considerably less than zero so with these forces, the pipe would be sloping down hill. Calculating (O-1) as a circular arc (pipe level at O) $R = 1627.6$ ft.

Using Equations 20 and 21 for the whole beam we get

$$M_a = O = M_{fa} - \frac{2EI}{L}\left(0 + 0 - \frac{3y_b}{L}\right)$$

$$M_b = O = M_{fb} - \frac{2EI}{L}\left(0 + 0 - \frac{3y_b}{L}\right)$$

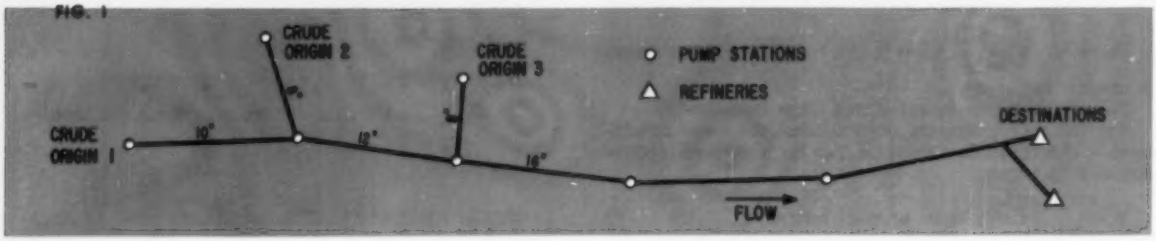
The loading can be adjusted so these equations are true. The moments between supports then can be calculated to determine maximum values.

References

1 and 2. Boyd, Jas. E. "Strength of Materials," p. 269-270, McGraw Hill Book Company Inc., New York, 1935.

3. Williams, Clifford D., "Analysis of Statically Indeterminate Structures," p. 167, International Textbook Company, Scranton, Pennsylvania, 1951.

GRAPHIC ENGINEERING DIGEST



Computers analyze economic feasibility of proposed pipelines

T. R. Young, *Shell Pipe Line Corporation, Houston, Texas*

The problem of pipeline investment analysis is complex and inherently active because old sources of crude play out and new ones are being discovered. It is complicated by the fact that the origin and destination of a proposed line are not always known prior to an economic study. A single oil discovery often is followed by nearby discoveries. The latter must be considered if designers are to maximize the likelihood for economic service for these later discoveries. Thus, alternative "origins" for the line must be studied. Similarly, the destination of a proposed line may be subject to question as the profitability of the crude delivered to different refining centers varies. Crude volume itself is another variable.

In addition, assumptions must be made for unit costs of construction and operation, line route, crude properties, tax rate, amount and repayment schedule for borrowed capital and for other parameters.

An analysis usually will include a computation of capital outlay, cash return, payout period, and yield on investment. It is often desirable to compute the data for each year of the projected life of the proposed line.

As these computations demand weeks of manual labor, the stored computer has been used to shorten the study time for such analysis. A number of programs have been written to handle different portions of the computation. Basically, the work is divided into **pipeline design, capital and annual operating cost estimates, and financial computation.** Wherever practicable, the output from one program is coupled with the subsequent program by common punched card format.

Design Calculations

Normal input to the design program includes **line length, terminal elevations, assumed diameter, crude properties, and range of line throughput.** In addition, values for pump and motor efficiencies, maximum permissible line pressure, and spare power also are read by the computer.

Output data are the number of pumping stations required in each segment of the system and the required power per station at each throughput level.

In a multi-year study, pumping stations will be added as throughput increases, according to one of several patterns. As stations are spaced at equal distance, assuming linear change of elevation with distance, the number of stations at successive expansion stages may be, alternatively:

(a) 1, 2, 4, 8, 16 etc.
(b) 1, 3, 6, 12, 24 etc.
(c) 1, 5, 10, 20, etc.

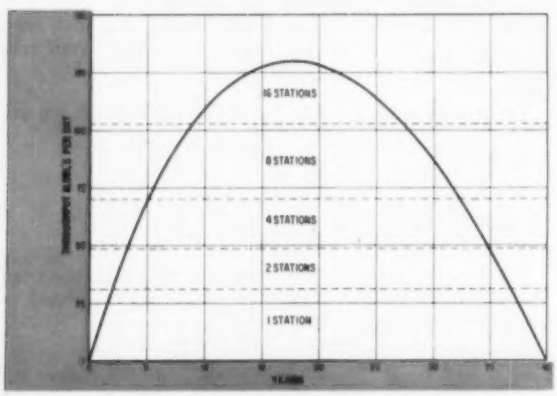


FIG. 2. Thruput vs. Station Requirements Curve.

The necessity for the next expansion stage appears in the computational program when the required discharge pressure exceeds the permissible line pressure. At that time the program will review its schedule of future throughput values to find the maximum, and compute the number of stations required, comparing them with the sets of arbitrary station series given above. If, for example, 22 stations were required at ultimate capacity, the mode of expansion would be selected, and further computation would be based on the expansion series, 3, 6, 12, 24. The criterion is the minimizing of excess stations at ultimate capacity.

Fig. 2. shows a typical line throughput curve with station requirements indicated at various volumes. This is needed to determine capital expenditure and operating expense.

The basic relations required in the design calculation may be written:

$$R_n = 92.2\, Q_l/Dv$$

$$P'_f = 0.042\, Q_l v g/D^4 \qquad R_n \leq 1000$$

$$P'_f = 0.0063924\, Q_l^{1.748} v^{.252} g/D^{4.748} \qquad R_n \geqq 1000$$

$$S = (P'_f L_k + \triangle h_k g/2.31)/(P_m - k_1)$$

Where S is non-integral, use next larger integer.

$$P_f = P'_f L_k/S$$

$$P_D = P'_f + k_1 + \triangle h_k g/2.31\, S$$

$$w = 0.000017\, Q_l P_D/\theta F$$

Capital Estimate

Required data: Number of stations and power unit costs for line and station construction, communications, river crossings, tankage, terminals, and miscellaneous costs.

Capital estimate is built up from (1) arbitrary expenditures (unrelated computationally to any other data in the computer, and including such items as terminals, river crossings, etc.) and (2) expenditures computable as extensions of unit costs multiplied by suitable bases. Bases used in this way include line throughput and length, number and power of stations, etc. Arbitrary expenditures are those requiring independent estimates based on engineering evaluations.

Design practice usually will vary depending upon the size of a pumping station, and it is necessary to select proper unit costs. Station cost is estimated as a base plus a unit cost per horsepower installed. Both base and unit values may vary according to the station power level, and a schedule of unit costs such as the following is contained in the input data.

Station power range bhp	Base cost $	Unit cost $/bhp
0—500	100,000	250
500—1500	300,000	200
1500—4000	600,000	190
4000—6000	900,000	180

The program makes an appropriate selection from the schedule above for estimation of pump station costs.

Cost elements recognized are **pipeline construction, pump stations, river crossings, terminal facilities, tankage, communications, miscellaneous, general project,** and **contingencies.**

The basic relation may be written:

$$C_i = (1 + k_3)\,(1 + k_2)\,[u_p L_k + R_k + T_i + S\,(b_k + b_k{}^* k_4 w) + k_6 k_5 Q_i + q_k + M_i]$$

Operating Cost

Annual operating expense is estimated similarly to the procedure for capital. Again there are (1) arbitrary costs that require engineering estimates, and (2) costs related to assumed or previously computed parameters.

The same problem of variable unit costs occurs here. As an example, station maintenance expense is estimated as a decimal fraction of station investment up to an arbitrary level at which point a smaller decimal fraction applies to all additional investment.

Cost elements recognized in this estimate are **station maintenance, fixed station operation, terminal operation, tank farm operation, pipeline maintenance, communication maintenance, oil loss, pumping power, miscellaneous,** and **administrative overhead.**

The estimating equations may be written:

$$J_5 = k_{20} S (b_k + b_k{}^* k_4 w) \quad \text{for } (b_k + b_k{}^* k_4 w) \leqslant U$$

$$J_5 = k_{20} S U + k_7 S\,[(b_k + b_k{}^* k_4 w) - U] \quad \text{for } (b_k + b_k{}^* k_4 w) > U$$

$$J_9 = o_k S + h_t + k_8\,(Q_i - H_t) + u_t k_9 Q_i + u_L u_p L_k + J_5 + u_c L_k + 365\,Go_v Q_i + m_i \quad \text{where } (Q_i - H_t) \geqslant 0$$

$$E_i = x_i + (1 + k_9)\,J_9 + B_a + k_{10}\,(Q_i - Q_B) + u_e w S$$

At first computer programs followed a nearly exact duplication of the usual manual procedure. However, a program can be generalized with an assortment of estimating bases. These provide flexibility. To illustrate, pipeline maintenance may be estimated by a unit cost per mile or by use of a unit cost per dollar of investment. It is done both ways, and the program should contain the arithmetic involved in both calculations. Thus, if

L = Line length, miles

u_L = Pipeline maintenance cost, $ per mile

I = Pipeline investment, $

u_I = Pipeline maintenance cost, $ per $ of investment

the pipeline maintenance may be written as $u_L L$ or $u_I I$. If the program executes both, either manner of estimate may be employed at will. The unit cost, u_L or u_I, that is not used should be read as zero, of course. This achieves two goals: (1) It gives a choice of estimating procedure and (2) it increases the probability that the estimating procedure may be duplicated by other organizations.

Financial Calculations

Basic Objectives. The previous work generates input data for financial calculations that evaluate the profitability of the proposed investment. Several kinds of information are needed for this purpose.

A detailed description of an investment may be made by

Computer Programming Nomenclature

Symbol	Description	Unit
	Hydraulics	
D	Inside diameter	in.
F	Load factor	dec frac.
g	Crude oil gravity	—
k_1	Pressure loss	psi per sta.
L_k	Length of segment	mi
P_D	Discharge pressure*	psi
P_f	Friction pressure drop*	psi/mi
P_m	Maximum allowable working pressure	psi
Q_i	Throughput	b/d
R_n	Reynolds number*	—
S	Number of stations*	—
v	Viscosity	cs
w	Power required*	bhp/sta.
ϕ	Pump and motor efficiency	dec frac.
Δh_k	Increase in elevation over segment	feet
	Capital	
b_k	Station base cost	$/sta.
$b_k{}^*$	Station unit cost	$/installed hp
C_i	Capital investment*	$
k_2	General project cost factor	dec frac
k_3	Contingency factor	dec frac
k_4	Factor for installed power over brake power	dec frac
k_6	Days storage required	—
k_5	Tanks cost, unit	$/bbl
M_i	Miscellaneous cost	$
q_k	Communications	$
R_k	River crossing cost	$
T_i	Terminal cost	$
u_p	Pipeline cost, unit	$/mile
	Operating and Maintenance Cost — Annual	
B_a	Administrative overhead, base cost	$
E_i	Operating cost, annual*	$
G	Oil loss	dec frac
H_t	Base throughput, (terminal cost)	b/d
h_t	Terminal operation, base cost	$
k_7	Station maintenance cost, secondary unit cost	$/$ invest
k_8	Terminal operation, unit cost	$/b/d
k_9	Other fixed general expense	dec frac
k_{10}	Administrative overhead, unit cost	$/b/d
k_{20}	Station maintenance cost, primary unit cost	$/$ invest
m_i	Miscellaneous operating cost	$
o_k	Fixed station operating cost	$/sta
o_v	Value of oil	$/bbl
Q_B	Base throughput (administrative overhead)	b/d
U	Break-point investment (station maintenance)	$
u_c	Communication maintenance cost, unit	$/mile
u_e	Energy cost, unit	$/bhp-yr
u_L	Pipeline maintenance, unit cost	$/$ invest
u_t	Tank farm operation, unit cost	$/b/d
x_i	Division and district office expense	$
	Financial	
c_n	Net book value, end of term	$
i	Year	—
k_a	Ad valorem tax rate	dec frac
k_d	Depreciation rate	dec frac
k_I	Income tax rate	dec frac
k_p	Earnings, basis investment	dec frac
k_t	Federal transportation tax rate	dec frac
n	Investment term	yrs
r_i	Cash realization, after tax	$
t_ϕ	Tariff required	$/bbl/100 mi†
Y	Investment yield	dec frac
Z	Salvage estimate	dec frac

*Computed data, all other data are input.
†For 1000 mi system. ($L_s = 1000$)

FIG. 3. EARNINGS PROJECTION — DELTA PIPELINE STUDY

Plan 106	Year	1	2	3	4	5
1	Capital additions	10250				
2	Net book value	10250	9890	9530	9170	8810
3	Earnings base	10250	9840	9328	8918	8508
4	Loan balance	8200	7872	7544	7216	6888
5	Thruput BPD	90000	90000	90000	90000	90000
6	Tariff ¢ per bbl	7.5	7.5	7.5	7.5	7.5
7	Revenue	2464	2464	2464	2464	2464
	COST OF OPERATIONS					
8	Operation and maintenance	545	545	545	545	545
9	Ad valorem tax	103	103	103	103	103
10	Transportation tax	160	160	160	160	160
11	Cost of operations	808	808	808	808	808
12	Interest	410	394	377	361	344
13	Depreciation	360	360	360	360	360
14	Subtotal	770	754	737	721	704
15	Total cost	1578	1562	1545	1529	1512
16	Profit before tax	886	902	919	935	952
17	Income tax	479	488	497	505	515
18	Profit after tax	407	414	422	430	437
19	Return on valuation %	4.0	4.2	4.5	4.8	5.1
20	Cash realization	767	774	782	790	797
21	Debt retirement	328	328	328	328	328
22	Net cash realization	439	446	454	462	469
23	Cumulative cash balance	439	885	1339	1801	2270
24	Allowable earnings	718	1000	1239	1441	1296
25	Excess earnings					
26	Cumulative excess earnings					

FIG. 4. Shell Pipe Line Rate of Return Computation
Total Investment

Plan 143 Year	Cash Expenditures	Cash Receipts
1	8625	1256
2		1279
3		1304
4		1330
5		1376
6		1405
7		1453
8		1502
9		1551
10		1601
11		1651
12		1722
13		1772
14		1842
15		1912
16		1990
17		2088
18		2166
19		2262
20		2357
21		2451
22		2563
23		2674
24		2784
25		2893

Rate of return, 16.80%.

displaying the schedule of cash outlay and cash return from the investment. This may amount to about 30 pieces of data. A more concise description may be had by reporting payout period. Another easily interpreted figure is investment yield. All three may be developed in an economic study, and additional perspective may be gained by computing tariffs required to earn stipulated returns.

Elements recognized are line throughput, capital expenditure schedule, operating expense, taxes, interest charges, and depreciation.

Year by year analysis. In detailed studies of projected investment a year-by-year profit and loss statement is necessary to determine earnings and cash realization. The program recognizes as many financial considerations as judged practical. They include:

(a) The maintenance of three sets of "books" over the period under analysis, tax book, company book, and a net investment figure based on special depreciation schedules prescribed by the Interstate Commerce Commission. Losses and earnings deficits are carried forward and act retroactively according to rules governing tax returns and allowable earnings.

(b) Tax depreciation options, straight line or declining balance.

(c) Borrowing of capital funds may be defined in detail, stating the percent of initial capital borrowed, of subsequent borrowing for expansion, and the individual percentage of original borrowing to be amortized in each year of the investment life.

(d) Optional use of the program for new or existing investments is possible.

(e) Tariffs may be allocated on different options. For a proposed system with multiple crude oil origins, the required per barrel transportation charge may be assessed equally to each crude oil origin. Alternatively, required transportation charges may be assessed to crude oil origins on the basis of miles of transportation furnished plus an arbitrary rate base.

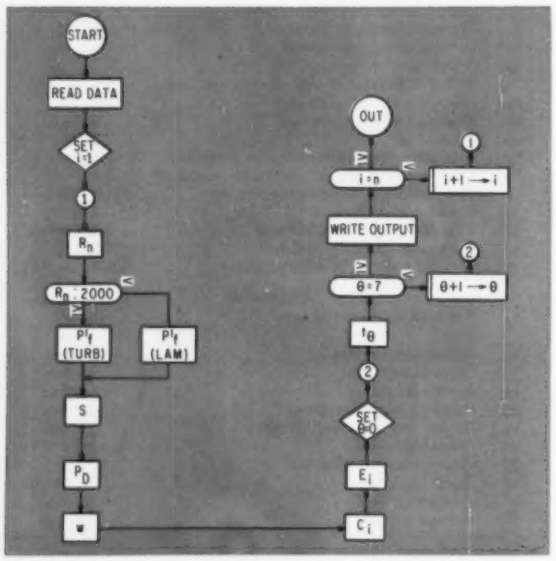


FIG. 5. Computer flow chart for tariff computation.

The various options and modes of computation outlined above are controlled by the program user by coding of input data to elect those desired.

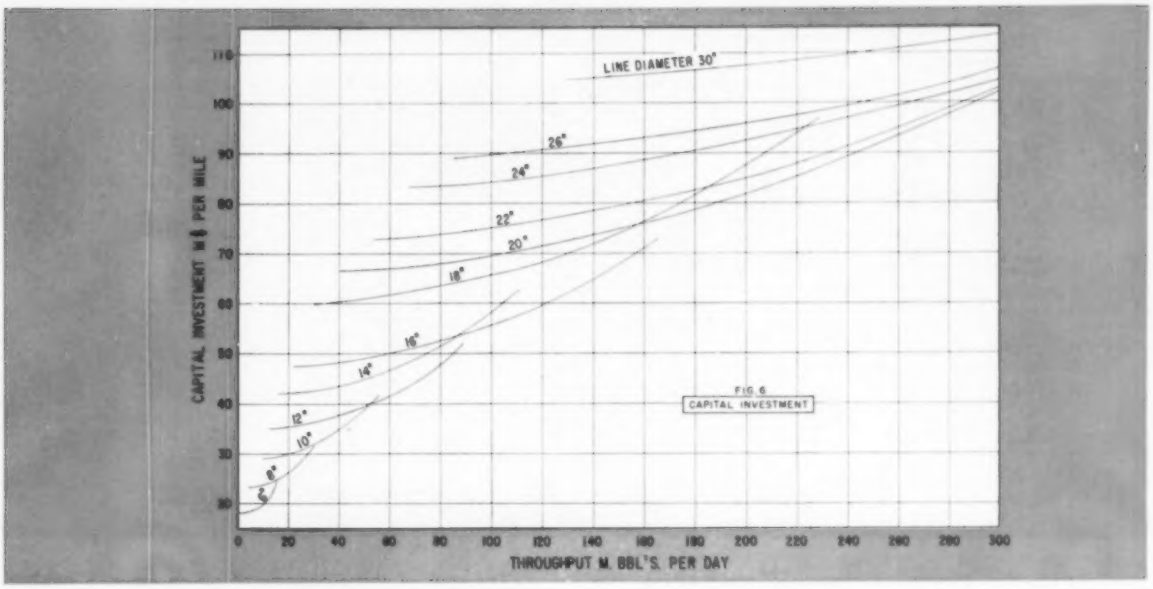
The computer outputs a year-by-year statement as shown in Fig. 3. Payout period for the investment can be determined by comparing the cumulative cash realization data (line 23) with the accumulated capital additions (line 1).

One-Year Analysis

The basic relations involved in the profit and loss statement shown below apply to a program for a single year computation based on average data. This program is normally used where many different values of line throughput and line diameter are to be studied.

Derivation of Tariff Equation

Capital investment	C_i
Throughput	Q_i
Revenue	$365\ Q_i t_a$
Operation cost	
Operation & maintenance expense	E_i
Ad valorem tax	$k_a C_i$
Federal transportation tax	$365\ k_t Q_i t_a$
Depreciation	$k_d C_i$
Total	$E_i + (k_a + k_d)C_i + k_t\ 365\ Q_i t_a$
Profit before tax	$365\ Q_i t_a - E_i - (k_a + k_d)\ C_i - k_t\ 365\ Q_i t_a$
Income tax	$k_t\ [365\ Q_i t_a - E_i - k_a + k_d)\ C_i - k_t\ 365\ Q_i t_a]$
Profit after tax	$k_p C_i = (1 - k_t)\ [365\ Q_i t_a - E_i - (k_a + k_d)C_i - k_t\ 365\ Q_i t_a]$



The equation expressing profit after tax is then solved for the tariff, t_o, required to earn k_p fraction of investment yielding:

$$t_o = \frac{k_p C_i + E_i + (k_a + k_d)C_i - k_I E_i - k_I(k_a + k_d)C_i}{365\,Q_i - k_t\,365\,Q_i - k_I\,365\,Q_i + k_i k_t\,365\,Q_i}$$

Use of the equation expressing required tariff as a function of capital and operating costs, line throughput, and required earnings is shown in Fig. 5. The flow chart outlines the computational procedure for a one-year study including design, capital cost, operating cost, and financial calculation procedures.

A typical use of the program is indicated by Fig. 6 to 9 showing how capital investment and tariffs vary with line size and throughputs.

Investment Yield

The computation of investment yield (rate of return) requires, as input data, a schedule of cash outlay (capital expenditures) and a schedule of cash return (cash realization), generated by the earnings projection program.

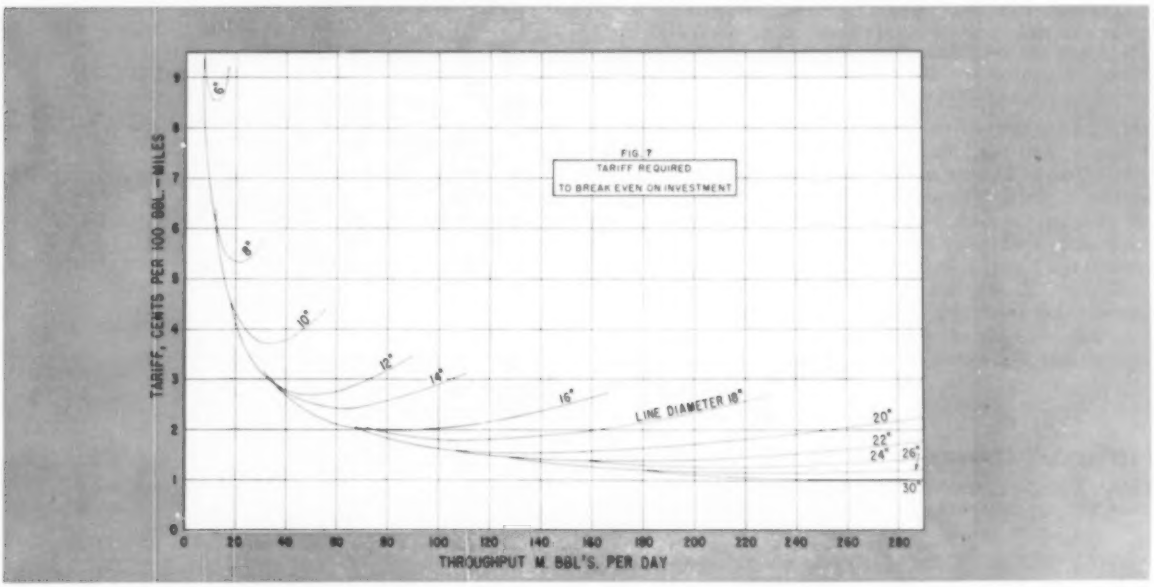
An example of investment yield as used here would be a borrowing of $1000 with interest of $50 per year for a period of 10 years when full repayment would be made. This represents a 5 percent investment. Supplement this with subsequent borrowings and irregular repayments and the investment would be analogous to pipeline investment.

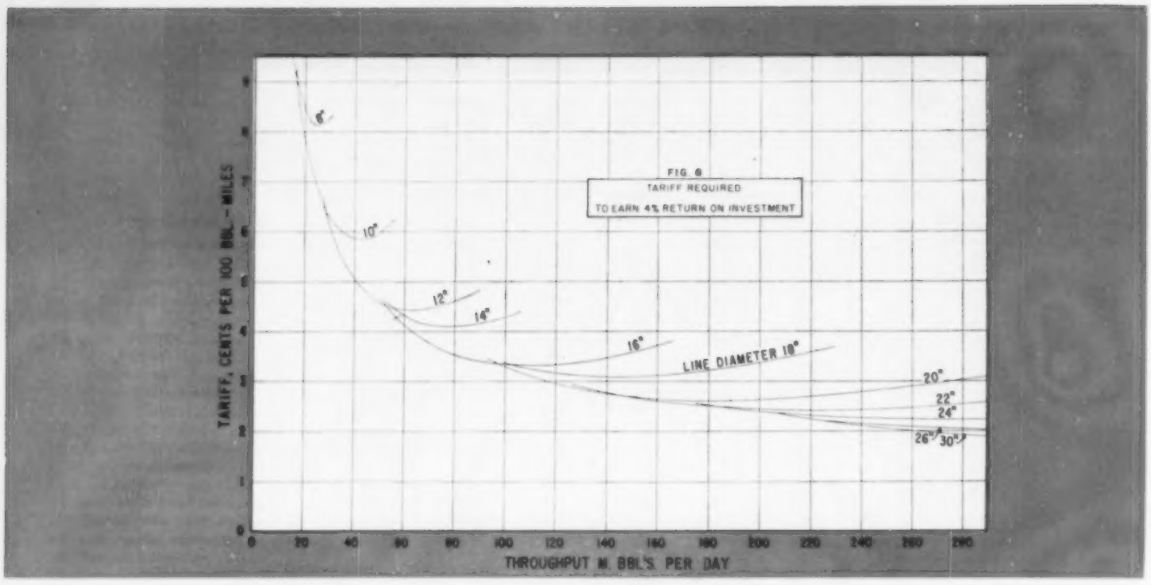
This is a complex mathematical problem, easily solved using automatic computation.

Applications

The programs discussed have been employed in economic studies of three major construction projects with total valuation approximating $80,000,000. In addition, other studies have been made dealing with investment planning for gathering systems and trunk line expansion. Also, general economic studies dealing with optimum pump station spacing and tariff policy are being carried out.

Yet the work reported here is only a part of the whole process of investment analysis. Much work in such analysis





lies outside the domain of electronic computation. For example (estimates of crude reserves, pipeline routes, design and construction practices must be made by engineers. Selection of those variables for study, including their ranges and interrelations, must be made. Output data from the various computer programs in turn are subject to final interpretation by the economist.

Equipment, Methods, and Staff

The work here employed an IBM 650 digital computer, utilizing 30 percent of a single shift. Other activities accounted for the remaining time.

Magnetic memory was found short in some instances and tape units probably will be added.

Systems used for programming include an assembler, an interpreter, and a compiler. These are the IBM Symbolic Optimum Assembly Program (SOAP II), the Bell Laboratories Interpreter, and the Purdue Compiler (IT), respectively.

All three systems have proved valuable and are selected according to the problem.

The staff of three consists of an engineer, a mathematician, and a programmer.

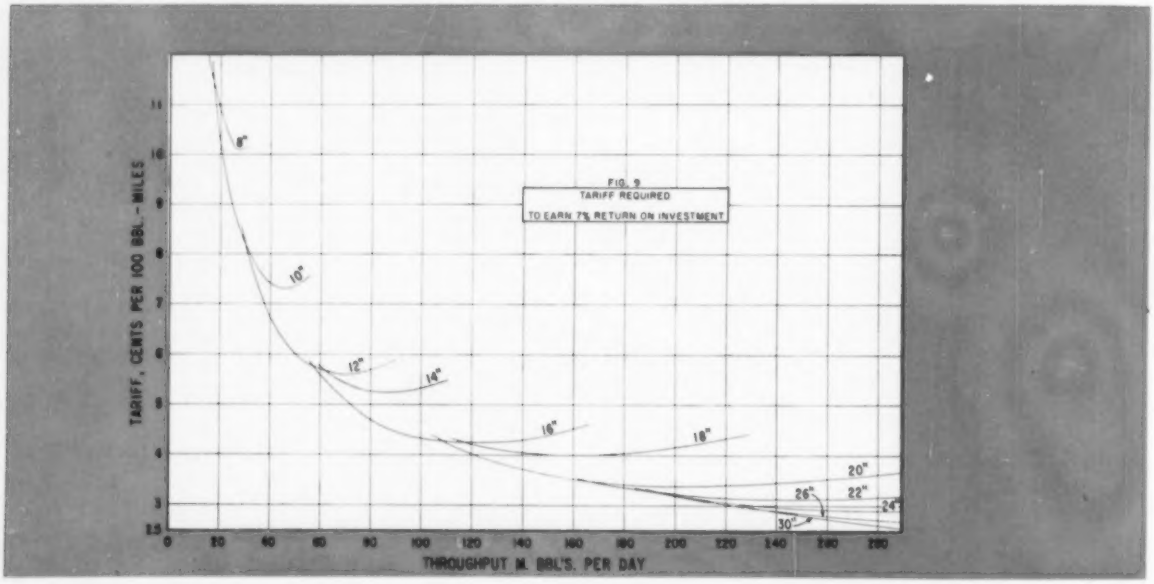
Conclusions

Benefits achieved with automatic computation include proof that simulation of pipeline operations is practical. Such simulation is now being extended to the scheduling of oil movements and operational control (selection of pumping units to minimize monthly power costs).

The computer has facilitated the extension of economic analysis, (a) to year by year treatment for greater accuracy and (b) to additional criteria for investment decision, such as investment yield. In addition, a larger number of economic variables can be evaluated by other than manual methods.

Acknowledgments

The author wishes to express appreciation to Robert Barton, Shell Oil Company, for long continued instruction and counsel in the application of automatic computing techniques, to Gerard Guyod, Shell Oil Company, for inventive and invaluable programming aid, and to Mrs. Sara Coate, Shell Pipe Line Corporation, for great assistance in the use of the programs reported here.



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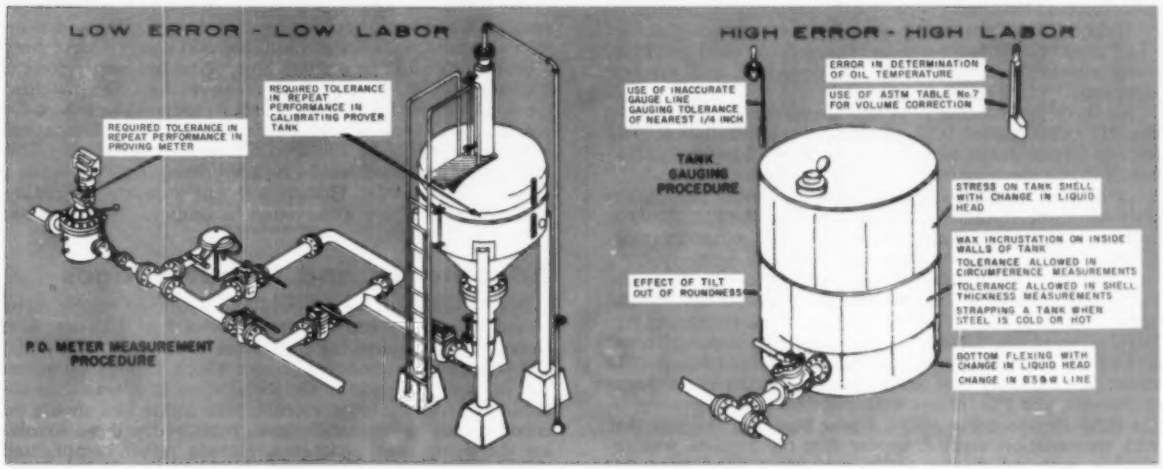

LOW ERROR - LOW LABOR
REQUIRED TOLERANCE IN REPEAT PERFORMANCE IN PROVING METER
REQUIRED TOLERANCE IN REPEAT PERFORMANCE IN CALIBRATING PROVER TANK
P.D. METER MEASUREMENT PROCEDURE
HIGH ERROR - HIGH LABOR
USE OF INACCURATE GAUGE LINE GAUGING TOLERANCE OF NEAREST 1/4 INCH
ERROR IN DETERMINATION OF OIL TEMPERATURE
USE OF ASTM TABLE No.7 FOR VOLUME CORRECTION
TANK GAUGING PROCEDURE
STRESS ON TANK SHELL WITH CHANGE IN LIQUID HEAD
WAX INCRUSTATION ON INSIDE WALLS OF TANK
TOLERANCE ALLOWED IN CIRCUMFERENCE MEASUREMENTS
TOLERANCE ALLOWED IN SHELL THICKNESS MEASUREMENTS
STRAPPING A TANK WHEN STEEL IS COLD OR HOT
EFFECT OF TILT OUT OF ROUNDNESS
BOTTOM FLEXING WITH CHANGE IN LIQUID HEAD
CHANGE IN BS&W LINE

Why pipelines favor LACT

L. S. Wrightsman, *Humble Pipe Line Company*

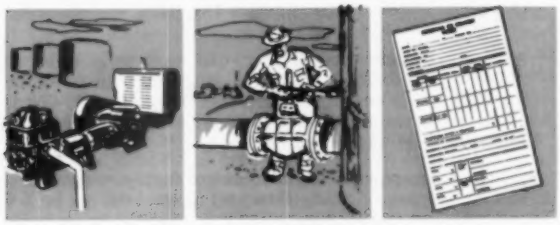
When a representative group of pipeline companies were surveyed not long ago concerning LACT, their replies indicated that the use of lease automatic custody transfer is expanding rapidly. If the present trend continues, the old, long established hand gaging procedure may be replaced.

Three Reasons

There are three reasons that account for pipeline companies' increasingly favorable attitude toward LACT. They are: (1) Reduction in pipeline gathering costs, (2) improved measurement accuracy, and (3) possible improved efficiency of pipeline gathering systems.

400,000 Trips Annually × $15 = $6-million!

Trip to lease . . . gage tank . . . shake sample.



Start pumps . . . return, shutdown . . . make ticket.

1. Reduction in Gathering Costs

It is a known fact that pipeline operators today are performing a service in gathering oil from producer's leases, the tariff or remuneration for which service is no greater, and perhaps in some cases less, than it was 10 to 20 years ago. On the other hand, the costs incident to this operation have increased several-fold over the same period of time.

Consider this hypothetical case. Assume a pipeline gathering company made 400,000 runs from leases in 1957. Each run required a gager to make a trip to the battery to gage the tank, test the oil for acceptability, determine gravity and BS&W. Then he must tank into line, start the pump, returning later on a second trip to shut down the pump, etc., and make run ticket. These operations normally must be witnessed by the producer's representative.

Costs per trip are from $4 to $7, and counting transportation, overhead, taxes, retirement, etc., the total comes to about $15 per run. The 400,000 runs would cost $6,000,000!

If the gager turns down 10 percent of the tanks this brings it to $6,600,000! With a tariff of 6 cents per bbl, the gross revenue comes to about $7,000,000 or a gross profit of only $400,000 before income taxes. This is a small return on a gathering system that might well cost $25,000,000.

Actual experience shows that a gager makes an average of one trip per day to a lease using old methods. **But using LACT, he will average no more than possibly two trips per month!**

2. Improved Measurement Accuracy

Two methods of measurement integral in LACT are far superior to hand gaging methods. They are the PD meter and the fixed volume measuring tank.

Measurement comparison. Humble Pipe Line Company ran tests to compare the accuracy of hand gage methods

with PD meter procedures, using one battery in three different fields on the Gulf Coast. The three crudes were different, one of the batteries was pumped into the system, the others flowed by gravity.

Three types of measurement were used at each battery: (1) Conventional hand gaging, (2) ground level gaging—using automatic level gagers, thermometers, and petcock sampling, and (3) PD metering.

All three agreed closely at two installations, but initially the PD meter varied 0.25 percent at one installation. The trouble turned out to be wax encrustation on inside of tank, which shows the magnitude of this type error.

Overall agreement was reached at the latter installation only after oil volumes were corrected to ASTM Table 6 rather than abridged Table 7 normally used in hand gaging. (Table 6 is the one commonly used with PD meters.)

After several months' operation of the three batteries the volumes had reached approximately 1,000,000 bbl and the agreement between the three methods of measurement was 0.015 percent when the hand measurements were corrected to 60 F by Table 6. From this it became obvious that the PD meter was far superior where wax encrustation was encountered, and PD meters were installed on 12 batteries in the field. Payout came within a year based on the fact that wax encrustation made it appear that the pipeline was receiving more oil than it really was when hand measurement was employed.

Unaccountable losses that appear in the annual statements of pipeline companies may in reality be caused by inaccuracies in measurement rather than physical losses. Improved measurement would be of great benefit to loss control programs.

Accuracy obtained by fixed volume or dump tank measurement is high for the following reasons:

1. Improved calibration using National Bureau of Standards certified test procedures. This is far more accurate than tank strapping measurements.

2. Electrical or pneumatic controls take care of switching of oil into and out of the dump tanks.

3. Automatic equipment eliminates the human element, which is a source of inaccuracies.

Dump tanks are often coated inside with plastic to reduce wax encrustation, as are the prover tanks used to calibrate them. Also, the dump tank normally fills and empties quickly, which should minimize wax deposition. Yet there will certainly be instances where dump tanks cannot be used because of the wax problem.

3. Improved Efficiency

This should be qualified as **possible** improvement in efficiency because there are certainly some differences of opinion on this particular phase of LACT. There are instances where pipelines are designed and equipped to empty a producer's tanks in a short time, most frequently for the convenience of the producer rather than the pipeline. Obviously if the LACT equipment is designed and sized for "around the clock" operations, lower capacity pumps and less energy would be required to serve the producer. This leveling off the load would be considered a step toward a more efficient system. Horsepower will certainly be reduced for batteries where production is only a few hundred barrels per month.

Advantages and Disadvantages

Before summarizing, I would like to discuss briefly some of the advantages and disadvantages of LACT. There is a trend among the pipeline companies to set up a policy that will stipulate the conditions under which LACT operations will be accepted, and if the installation is operated in accordance with the requirements, little difficulties should be encountered. Some installations, particularly those involving the dump tank procedure, include rather complicated electrical or pneumatic controls; however, experience seems to indicate that in spite of the somewhat elaborate controls, in most cases little difficulty is experienced.

It might appear that LACT installations using a PD meter are perhaps somewhat simpler, with considerably less complication due to controls, etc. On the other hand, in metering operations one of the chief requirements is the complete prevention of air entering the meter and, of course, the meter must be proved or calibrated at regular intervals. Provided the proper facilities are available, little difficulty should be encountered with air, and meter proving procedures are now well established and not considered to be a particular handicap. Certainly by regular calibration, the accuracy of the meter measurement operation is perhaps more clearly defined that would be the case with the dump tank procedure.

Summary

As present trends continue, the old long established hand gaging procedure may be replaced in many cases by automatic measurement. It would appear that the future of LACT is quite clear. We have shown that greater economy, improved accuracy, and improved efficiency will result by the use of this type of measurement. It appears from the survey that the pipeline companies favor LACT, perhaps to the extent that in many cases installation will be instigated by the pipeline even though the general feeling seems to be that perhaps the producer has more to gain.

What 10 Pipeline Companies Said About LACT

These five questions were asked 10 pipeline companies—that handle collectively 7,000,000 bbl of oil per day (1957 averages):

Q. As a pipeline operator, are you generally in accord with the automatic custody transfer procedure for measuring lease runs?

A. Yes.

Q. Do you prefer to receive into a gathering system by PD meter or by fixed volume dump tank measurement procedure?

A. The answers indicated a slight preference for the PD meter. However, in some instances, PD meters had not been tried. Some preferred meters but used both procedures—others had reached no decision.

Q. Are you presently engaged in receiving oil into your gathering system by either method; if so which?

A. Practically all said yes. Some used both methods. In a few cases official measurement had not begun, but experimental work on both was underway.

Q. Do you have written standards which you require a LACT installation to meet?

A. About 75 percent said yes—25 percent, no. In some case standards will be forthcoming.

Q. What is your company policy regarding who furnishes the LACT equipment?

A. Majority said the producer had most to gain, therefore he should furnish the equipment. In other instances, no definite pattern had been formed, and in a few cases the answer seemed to depend somewhat on the particular circumstances.

Summed up, pipeline companies are highly interested in LACT, but types of equipment and procedures to be followed have not yet been standardized.

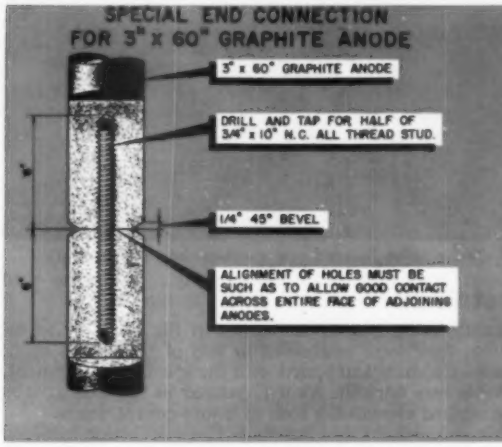

SPECIAL END CONNECTION
FOR 3" x 60" GRAPHITE ANODE
3" x 60" GRAPHITE ANODE
DRILL AND TAP FOR HALF OF 3/4" x 10" N.C. ALL THREAD STUD
1/4" 45° BEVEL
ALIGNMENT OF HOLES MUST BE SUCH AS TO ALLOW GOOD CONTACT ACROSS ENTIRE FACE OF ADJOINING ANODES.

FIG. 1. Special end connection for 3-in. by 60-in. graphite anode.

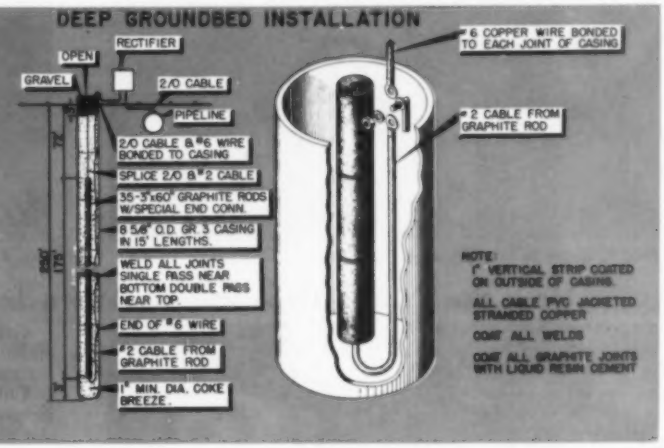

DEEP GROUNDBED INSTALLATION
RECTIFIER
OPEN
GRAVEL
2/0 CABLE
PIPELINE
2/0 CABLE & #6 WIRE BONDED TO CASING
SPLICE 2/0 & #2 CABLE
35-3"x60" GRAPHITE RODS W/SPECIAL END CONN.
8 5/8" O.D. GR. 3 CASING IN 15' LENGTHS.
WELD ALL JOINTS SINGLE PASS NEAR BOTTOM DOUBLE PASS NEAR TOP.
END OF #6 WIRE
#2 CABLE FROM GRAPHITE ROD
1" MIN. DIA. COKE BREEZE
#6 COPPER WIRE BONDED TO EACH JOINT OF CASING
#2 CABLE FROM GRAPHITE ROD
NOTE:
1" VERTICAL STRIP COATED ON OUTSIDE OF CASING.
ALL CABLE PVC JACKETED STRANDED COPPER
COAT ALL WELDS
COAT ALL GRAPHITE JOINTS WITH LIQUID RESIN CEMENT

FIG. 2. Deep groundbed installation.

High resistance soil problem solved by deep groundbeds

Robert L. Bullock, *Interstate Oil Pipe Line Company, Shreveport, Louisiana*

SEVERE CORROSION on Interstate Oil Pipe Line Company's system in parts of Mississippi where soil resistance was high and electric power scarce, limited cathodic units to high current output rectifiers. Experience with rectifiers using normal surface groundbeds, vertical graphite rods with coke breeze backfill spaced 10 to 20 ft apart, had proved costly in the high resistance soil. Search for pockets of low resistance soil turned up only one usable location—with the low resistance soil lying below a stratum of high resistance surface soil.

Interstate successfully installed first a single vertical steel groundbed, deep enough to penetrate into the low resistance zone. The low circuit resistance and long protective spread obtained by this unit, led to similar deeper units.

Successful installation of a deep groundbed in high resistance soil proved that while low resistance soil is preferred, it is not necessary in order to obtain a low resistance groundbed. And a deep graphite coke breeze backfill groundbed has a life expectancy of 20 or more years.

Problems of Design

Repairs to a deep graphite-rod groundbed would be almost impossible. So the first problem was to devise a means of joining the 3-in. by 60-in. graphite rods to prevent a break in the string of rods, which might cause a reduction in length of the groundbed and reduce its effectiveness. Fig. 1 illustrates the solution to this problem. The rods and studs were custom built and a special resin base cement sealing agent, compatible with the characteristics of graphite, was used for making up the joints in the field.

The next problem was how to install a continuous graphite rod down a mud-filled hole drilled 250-ft deep and at the same time place coke breeze uniformly and free of mud around the rod. Normal groundbeds had shown severe necking of the rods where soil penetrated the coke backfill. Solution to this problem was to run the graphite rods and coke backfill inside reclaimed 8⅝-in. pipe. This casing was regarded as sacrificial and this called for complete and uniform disintegration because any portion not consumed would shield the rods and breeze. Expected life of the 250-ft, 28-lb casing is proportionate to current output of the rectifier: 11.6 years for 30 amp; 5.8 years for 60 amp.

The adopted plan is shown in Fig. 2. A continuous wire was run as shown, connecting every joint and the top and bottom graphite rods. This insured continuity even if the pipe separated.

Gas blocking was not considered serious because of the very low current drainage. To facilitate movement of gas up the coke breeze, however, particle sizes were specified between ½ and 1 in. diam.

FIG. 3. Graphite rod with stud, first step.

FIG. 4. Casing being lowered over graphite rods, second step.

How the 250-ft Groundbeds Were Installed

FIG. 5. Bonding joints of casing, second step.

First, 250-ft holes were drilled—2 in. larger than the 8⅝-in. casing—and the pipe, bull-plugged on the lower end was welded into the hole joint by joint as graphite rods were made up in the center of the casing and packed with coke breeze.

The first joint was lowered into the hole. This joint was 18 ft long (all others were exactly 15 ft) and bull plugged, with the bottom 3½ ft filled with 1-in. coke breeze. After the pipe was in the hole, a 15-ft long joint of three 3-in. graphite rods, with a 15-ft long No. 2 cable attached, was lowered on top of the breeze with the upper end protruding 6 in. above the top of the pipe. The cable was bonded to the lug on the interior of the pipe (see Fig. 2) and the void between the casing and the string of rods was filled with coke breeze.

Next, a second set of three graphite rods was attached to the first set, and a 15-ft joint of casing was lowered over the rods (see Fig. 4). No. 6 wire was fed through the second joint of casing and bonded to the first joint (see Fig. 5). The second joint was then lowered and welded to the first. The drilling rig then lowered the string in the hole, and the upper end of the No. 6 wire was bonded to the second joint of casing. The void between the graphite rod and casing was filled with coke breeze. The casing string was then filled with water to add needed weight.

The previous step was repeated until all rods and casing were installed. Coke breeze was added to all joints, stopping within 3 ft of the surface of the ground. The last 3 ft was filled with gravel to filter surface water that might enter the casing.

Drilling. The hole should be straight, free of cuttings and 2-in. larger than the casing.

Casing. Casing should be straight and squarely beveled. The 15-ft joints proved practicable in this case.

The terminal post shown in Fig. 2 was welded inside the upper end of each joint, and a metal lug was welded to the outside to enable the elevators on the drilling rig to pick up the pipe.

A 1-in. wide strip was cleaned and coated the length of the casing (as were the welds). The purpose—to insure continuity in the full string of casing during the final stages of its consumption.

Graphite rods. Details are shown in Fig. 1. Prior to installation, they were assembled in sets of three rods each, fastened with studs and sealed with the special resin cement.

Coke breeze backfill. As it is poured in the casing, it is lightly tamped around the rods to insure compactness.

Cable connections and bonding. The connection between the cable and the string of rods should be tight and sealed with resin cement. Special care should be taken in making the splice between the No. 2 cable on the bottom rod and the No. 6 wire and the splice between the No. 2 cable on the top rod and the 2/0 cable. Insulation applied over these splices consists of Kearney Air Seal to form out the splice, two layers of Okonite tape, two layers of Okoprene tape, two layers of Scotch No. 33 tape, and a final layer of friction tape. All completed bonds to the casing should be primed and then coated with hot applied coal tar enamel.

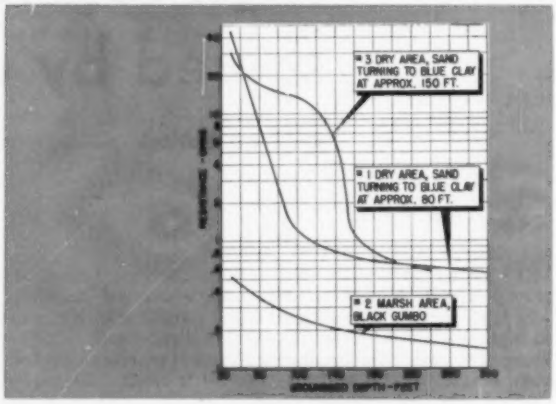

3 DRY AREA, SAND TURNING TO BLUE CLAY AT APPROX. 150 FT.
1 DRY AREA, SAND TURNING TO BLUE CLAY AT APPROX. 80 FT.
2 MARSH AREA, BLACK GUMBO

FIG. 6. Circuit resistance log of deep groundbeds, resistance vs depth.

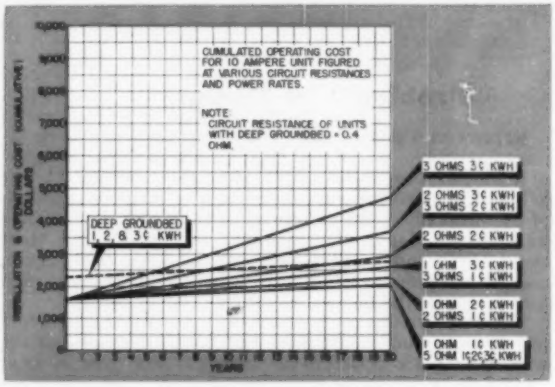

CUMULATED OPERATING COST FOR 10 AMPERE UNIT FIGURED AT VARIOUS CIRCUIT RESISTANCES AND POWER RATES.
NOTE: CIRCUIT RESISTANCE OF UNITS WITH DEEP GROUNDBED + 0.4 OHM.
DEEP GROUNDBED 1, 2, & 3¢ KWH
3 OHMS 3¢ KWH
2 OHMS 3¢ KWH
3 OHMS 2¢ KWH
2 OHMS 2¢ KWH
1 OHM 3¢ KWH
3 OHMS 1¢ KWH
1 OHM 2¢ KWH
2 OHMS 1¢ KWH
1 OHM 1¢ KWH
5 OHM 1¢,2¢,3¢ KWH
YEARS

FIG. 7. Cost comparison, deep scrap metal and normal groundbeds. (Minimum power charge assumed.)

Costs

A breakdown of costs of installing a deep groundbed, material and labor, is given in Table 1.

A log of circuit resistance of the casing and pipeline at each site was taken as the casing was lowered and plotted, as shown in Fig. 6. These data indicate there was no need to go below 250 ft to get a low resistance groundbed in high resistance soil.

The circuit resistance of each completed rectifier unit (determined from the voltage and current output) was lower than the resistance determined at the time groundbeds were installed. Resistances have gradually increased as expected and have leveled off, but are still below the first value determined.

The protective spread realized from rectifier units with deep groundbed is approximately one-third more than that obtained from units of like current output employing regular suface-type groundbeds. This is probably due to the position of the groundbed (anode) in relation to the pipeline (cathode) and the low circuit resistance of the deep groundbed unit.

Extensive tests by others have shown that interference problems with foreign structures are practically non-existent when deep groundbeds are employed, especially when the resistance of the groundbed is below 1 ohm. Tests at site No. 2 employing a normal surface-type groundbed show serious anodic interference with foreign lines with bonding drainage up to 20 percent of unit output required to avoid damages. Tests with the deep groundbed at this site show only slight change from off to on of unit with no bonding required.

TABLE 1

Drilling			
Hole drilled 250 ft and set casing...	at $ 2/ft		$ 500.00
Materials			
33—3 in. x 60 in. graphite rods.	at	10.50	346.50
2—3 in. x 60 in. graphite rods. with cable.....	at	12.85	25.70
100 ft—2/0 PVC cable.....	at	.35	35.00
250 ft— No. 6 PVC wire.....	at	.11	27.50
4,500 lbs—coke breeze.....	at	.056	252.00
15 lbs—resin cement.....	at	1.32	19.80
250 ft—Grade No. 3, 8⅝ in. casing	at	.85	212.50
Lot—misc. connections.....		5.00	5.00
	(Material Total		$ 924.00)
Supervision, labor and expense.....			745.00
	TOTAL COST		$2,169.00

Performance Data

A soil resistance survey was made at each site selected, employing the four-terminal method. Separation of terminals was varied from 5 to 100 ft, giving an average soil resistance down to 100 ft. These data are presented in Table 2.

TABLE 2

Depth in feet	Resistance in Ohm-Cm		
	Site No. 1	Site No. 2	Site No. 3
5	32,000	240	46,000
10	13,200	180	42,000
15	5,100	180	45,000
20	8,000	200	52,000
50	12,000	100	78,000
75	—	160	105,000
100	4,000	200	70,000

Valuation of Deep Groundbeds — Conclusion

The advantages of employing deep scrap metal or graphite groundbeds are given below:

1. Affords low resistant groundbeds in high resistance soil, thus making possible economic protection to bare pipeline in high resistant soil.
2. Geometric location in relation to pipeline and low circuit resistance gives extensive coverage.
3. Interference problems with foreign structures are minor.
4. Engineering and corrosion surveying costs in locating low resistant soil are eliminated.
5. Expensive rights-of-way are reduced and can be eliminated, as deep groundbeds can be located on existing pipeline rights-of-way.
6. Resistance remains more constant with seasonal changes.
7. The advantage of deep groundbeds over conventional graphite beds is emphasized in cost comparisons, Fig. 7, 8, and 9. Installation cost includes groundbed, connecting cable, and mounted rectifier. An average installation cost was used for the conventional surface groundbed examples. These costs would be higher for high resistance soil and lower for low resistance soils. A minimum power charge is assumed for the deep groundbed in Fig. 7. The deep groundbed in Fig. 7 is a scrap metal type, whereas those in Fig. 8 and 9 are graphite rod types. Scrap metal is more economical than graphite if a life of 15 or more years can be expected.

Acknowledgment

The author wishes to acknowledge the assistance given by Paul Miles, William H. Mitchell, Jr., and Wilson L. Pevy of Interstate's engineering staff in compiling data for this paper.

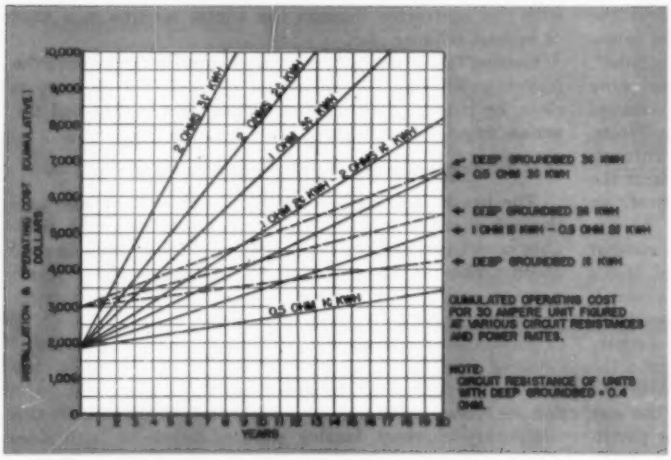

INSTALLATION & OPERATING COST (CUMULATIVE) DOLLARS
YEARS
DEEP GROUNDBED 36 KWH
0.5 OHM 36 KWH
DEEP GROUNDBED 28 KWH
1 OHM 28 KWH - 0.5 OHM 28 KWH
DEEP GROUNDBED 18 KWH
0.5 OHM 18 KWH
CUMULATED OPERATING COST FOR 30 AMPERE UNIT FIGURED AT VARIOUS CIRCUIT RESISTANCES AND POWER RATES.
NOTE: CIRCUIT RESISTANCE OF UNITS WITH DEEP GROUNDBED = 0.4 OHM.

FIG. 8. Cost comparison, deep graphite rod and normal groundbeds.

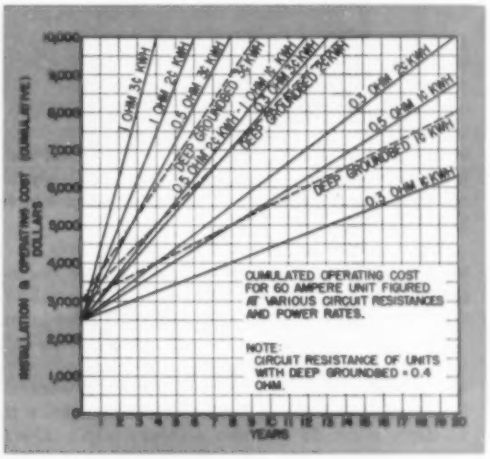

INSTALLATION & OPERATING COST (CUMULATIVE) DOLLARS
YEARS
1 OHM 36 KWH
1 OHM 26 KWH
0.5 OHM 36 KWH
DEEP GROUNDBED 36 KWH
0.5 OHM 26 KWH
1 OHM 18 KWH
0.5 OHM 18 KWH
DEEP GROUNDBED 28 KWH
DEEP GROUNDBED 18 KWH
0.2 OHM 26 KWH
0.2 OHM 18 KWH
0.2 OHM 8 KWH
CUMULATED OPERATING COST FOR 60 AMPERE UNIT FIGURED AT VARIOUS CIRCUIT RESISTANCES AND POWER RATES.
NOTE: CIRCUIT RESISTANCE OF UNITS WITH DEEP GROUNDBED = 0.4 OHM.

FIG. 9. Cost comparison, deep graphite rod and normal groundbeds.

P 615.3 P 623.

Pipeline Fundamentals

Brush gang fells a tree.

Ripper works ahead of the ditching machine.

CONSTRUCTING THE LINE

Robert E. Gregory
Gulf Interstate Gas Company

Putting a pipeline together is a masterpiece of teamwork, skill, patience, endurance, and ingenuity. Over good terrain and bad, the new line creeps onward, pushed into the ground by men whose lives are punctuated with the terms of a tough trade — mucker, ditch man, "fire in the hole!", stinger, and countless others that have grown up and come of age through the accumulated experience of a thousand construction jobs all over the world From these projects, work patterns develop, are improved or discarded. Through it all, the contractor's key men work furiously to beat the clock, for time is money — the pivot upon which profit or loss may hinge.

What would be a task force in the Navy, or a combat team in the Army, is a "spread" in pipeline language. It is a group of specialists who can do any job of pipeline construction in the geographical area to which they've been assigned.

The boss is the spread superintendent, and he's a pretty big man. The Spread Man will usually move in on a job with about a dozen supervisors who have worked with him for years and can tell what he had for breakfast by the way he slams a car door. These men are responsible for particular segments of the finished job — the right-of-way, ditch, pipe, lowering-in, dope, welding, etc. Behind the men supervising these operations are other old-timers — machine operators, welders, dynamite men, casing men, etc., who stick with the contractor through the winter months in a kind of mutual reliance pact.

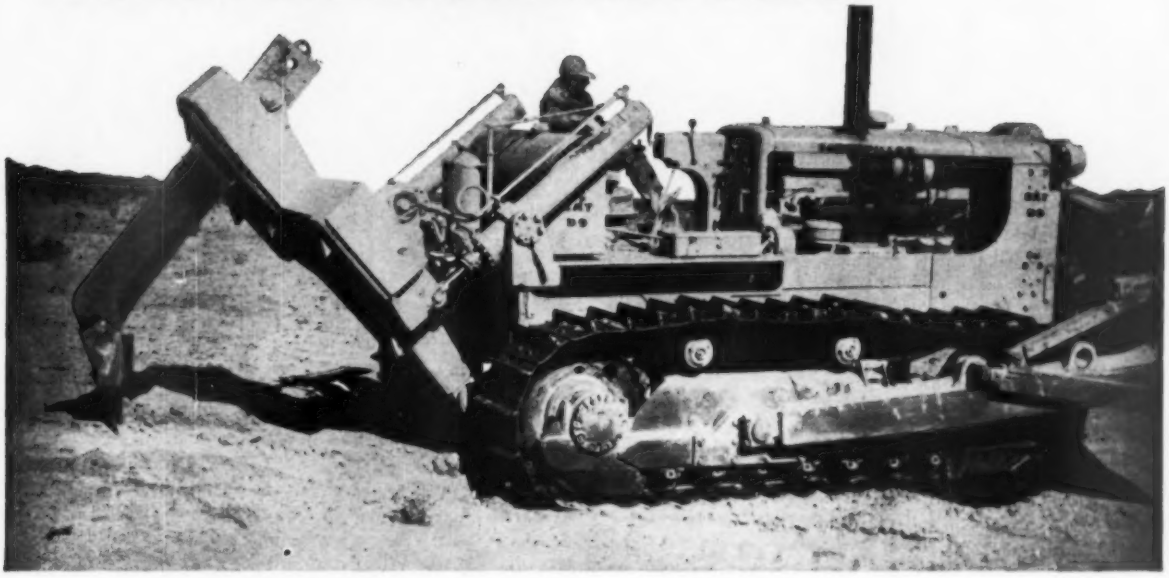
Getting the land rights and making the survey aren't the contractor's jobs. But when he's notified that the way is clear, he moves in his spread on the right-of-way and the action begins. First comes:

CLEARING THE RIGHT-OF-WAY

The brush gang moves down the right-of-way like ants through a candy factory. Axes ring, machetes swing, portable saws buzz, and the burn piles smolder as they feed on green timber. Prime requisites for a member of the brush gang are strong back and legs, a steady eye, and no particular fear of snakes or spiders.

As the brush crew moves on, the clearing dozers move in, leveling and uprooting stumps and knee-high brush left behind by the gang. The dozer operators blade out room for the heavy traffic that will shortly follow them down this temporary highway, leaving piles of debris on both sides of the stripped right-of-way to be carried off or burned. Now the 66-ft wide strip (this varies) is ready for ditching.

RIPS DEEPER
THROUGH FROST AND ROCK



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C-R-C manufactures a full line of rippers to fit almost every tractor. Get full details by calling or writing C-R-C in Houston, Texas.

C-R-C Kelley Coal Ripper shown making a pass through a strip mine. Penetration depth is a maximum 7 feet.

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Wagon drill in action.

DITCHING

Contract specifications require the line to be buried generally with 30 to 36 in. of cover. In rock the cover may be from 12 to 24 in. Road and river crossings must be put in deepest.

Ditching to 6 ft through soft, sandy soil isn't too much of a problem. Stakes are set, and the ditcher goes to work. In rock country a ripper is used ahead of the ditching machine. The ripper is a 6-ft, massive steel hook, hydraulically operated from a heavy crawler tractor. The operator sights on the stakes set down the middle of the right-of-way, starts up and lowers his hook to full depth. The ground is literally torn apart as he makes three passes over each section. The ripper thus performs two tasks—it loosens the soil for the ditching machine and it finds rock formations too solid for the ditcher to remove.

The ditching machine looks something like a stern-wheeler that has somehow wandered onto dry land. As the revolving buckets bite into the soil and deposit it on a conveyor belt, the huge machine inches forward in the track of the ripper, leaving behind a neat pile of backfill beside a clean, straight ditch. When the ditcher runs onto rock, he pulls up his wheel and lumbers onward to the next "good" stretch, leaving the rock to the drillers, dynamite men, and the muckers. The ditching machine also bypasses highways and streams either too deep or too rocky for it to handle. These jobs must be done more or less as ditching specialties.

DITCHING SPECIALTIES

Bedrock and hillsides go together in some areas, and the rock-bottomed stream is not uncommon. When rock is encountered, a drilling apparatus called a twin wagon drill is moved over the ditch area, holes are drilled, dynamite tamped, and the section shot to blast out the rock. Debris

Road crossing.

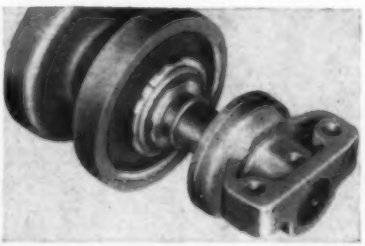
Pipe is strung along the right-of-way.

built for pipeline work

Carbody . . . wide and heavy to withstand stress. Three-piece removable bottom cover plate. Hinged center panel.

Crawler End Tumblers equipped with bronze seal rings.

Swing and Travel Shafts . . . large diameter with involute splining for greater reserve strength.



Crawler Rollers protected by bronze seal rings and by neoprene rubber O-rings.

The challenge of pipeline work has been a good test for the ruggedness and dependability of Insley excavators and cranes. Insley's wide-spread popularity and leadership in the pipeline construction field prove Insley's capability in meeting this challenge.

The Insley Pipeliner is *built* for pipeline work. It is a high performance machine with the durability that the tough jobs demand.

Heavy Duty Hoe Attachment • Box-Type Jackframe • Optional: Two-Speed Travel • Tractor Type Crawlers • Brake Type Cab Lock • Independent Boom Hoist • Independent Travel

THERE'S AN **INSLEY** WORKING NEAR YOU

INSLEY MANUFACTURING CORPORATION
GENERAL OFFICES—INDIANAPOLIS 6, IND.
WEST COAST DIVISION—LOS ANGELES 54, CALIF.
THE MAXI CORPORATION (Subsidiary) LOS ANGELES 54, CALIF.

Bending pipe in the field.

is then clammed out by a backshoe or dragline, sometimes on such steep inclines that tractors must be used to hold the shovel in position on the side of the hill.

If rock or rivers aren't problems there are always the highway crossings. When the ditch reaches a highway, it must go down and under. This calls for extra deep ditch to get the boring machine in operation. The borer drills a hole under the road, supports are put in, and the hole made ready for the heavy-wall pipe or casing that will be pulled or pushed through to join the pipeline on both sides of the road.

Special jobs like these are scouted ahead of time, and the work leap frogs ahead of the spread. Back where the ditch has been opened the pipe is being laid out on the right-of-way in an operation called stringing.

STRINGING

Pipe has been ordered and scheduled for delivery months before the contracts were let. It now appears on the right-of-way, hauled in from railway delivery points by trucks specially rigged with pipe trailers. Joints of pipe are carefully boomed off the trailers and laid end-to-end alongside the ditch. Some of the pipe has been bent at the mill to specifications called for in the contract. Other straight pieces will be bent in the field as the terrain may require. This work is done by a bending machine, which follows the stringer down the right-of-way.

As soon as any appreciable amount of pipe has been strung and the proper bends made, the pipe gang goes to work.

LINEUP AND TACK WELD

Using lineup ring clamps and the internal lineup clamp, the pipe gang hustles joints of pipe together to be tack-welded, ready for the stringer bead welders. As the pipe joints are constructed, they are placed on skids so subsequent operations may be performed more easily. Here the skill of the sideboom tractor operators come into play, for they must work together to raise or lower long sections of pipe on signal from the gang foreman.

On the pipe gang, everyone has to be alert at all times, for this is the sort of work where injuries can easily occur from one lapse of attention.

WELDING

Welding, the heart of any pipeline construction, is the next operation. First are the stringer bead welders, the elite of a very fine company. Nobody welds on a pipeline merely because he walks up and says he's a welder. Every welder is tested thoroughly before being hired. But the stringer bead man has to be an artist in his trade, for unless the initial bond between two joints of pipe is solid, anything put on top of it is going to waste. Thus, the stringer bead is run by a picked crew who do nothing else.

Following the stringer bead comes the hot pass and cap, work performed by teams of welders on the "firing line." Welding inspectors from the company inspect every weld, both visually and with the industrial X-ray machine. If a bad weld is discovered it is cut out and replaced, for eventually the line must be tested beyond ordinary working pressures, and this test is the proof of the pudding for welders and inspectors. As the caps are put on each welded joint the coating and wrapping operation begins.

Pulling line-up clamp through pipe.

Tack welding a joint.

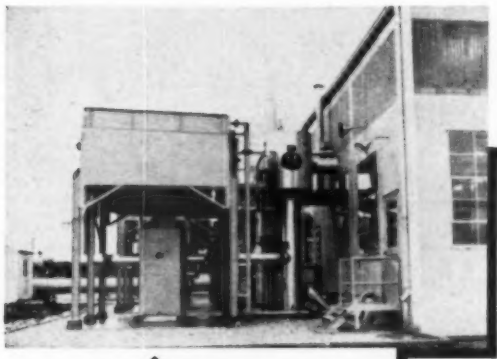
UNITED GAS PIPE LINE CO. INSTALLS VAPOR PHASE®

to cool 3 compressor units with own waste heat

System Increases Engine Output and Life; Reduces Cylinder Wear; Would Permit Use of Sour Gas Fuel

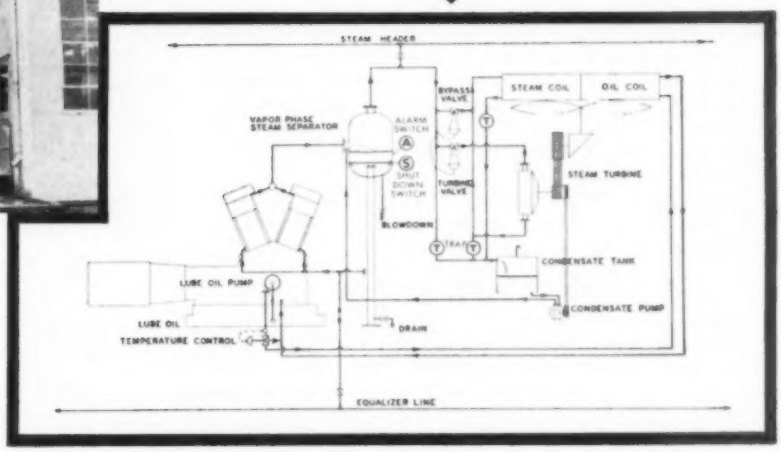
The 3-880 H. P. Gas Compressors at UGPL's Cabeza Creek station, near San Antonio, Tex., installed in 1957, are taking the power to drive their cooling fans from the waste heat of their own operation. The formerly wasted heat is taken from the VAPOR PHASE® separators in the form of low pressure steam. This steam drives the cooling air fans through steam turbines, an exclusive patented feature of the Vapor Phase System.

The decision to install Vapor Phase® Thermal Circulation Cooling was based on the successful operation of a similar installation, made in 1953, on 5-880 H. P. engines at UGPL's Agua Dulce Station which resulted in better combustion, reduced cylinder and ring wear and lowered operating costs.



CABEZA CREEK STATION — Steam generated from waste heat passes through Vapor Phase® Steam Separator and operates turbine driven fan, condensing the steam and cooling the lube oil. Operating costs are reduced while freeing the engines for greater power output.

VAPOR PHASE® FLOW DIAGRAM — water and steam from the engine power cylinders flow through a header to the Vapor Phase® steam separator. Steam produced powers the turbine driven fan which furnishes air to dissipate engine heat. All condensate is returned to the water and steam header. Water from the separator circulates through the power cylinder jackets by gravity.



"Sole Developers and Manufacturers of Vapor Phase® Thermal Circulation (Ebullition) Engine Cooling"

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ENGINEERING CONTROLS, Inc.

AN AFFILIATE OF ST. LOUIS SHIPBUILDING & STEEL CO.

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COATING AND WRAPPING

Before the pipe can be put into the ditch, it must be cleaned externally and given a special coating and wrap to help protect it against corrosion. Cleaning and priming is done by a machine with revolving wire and hair brushes, and right behind this operation comes the coating and wrapping machine. The latter applies a uniform layer of hot dope to the primed pipe and covers it with layers of glass fiber, asbestos felt, and kraft paper, all in one operation.

After the "green" dope has set up, detectors are run over the coated pipe to search out pinholes, called "holidays" by pipeliners. When a fault is found in the coating, the "holiday detector" emits an electric spark and the spot is marked for patching. Such places are hand patched by the dope gang.

Although much of the coating and wrapping of pipe is done on the job, in many instances it is coated in plants that make a specialty of this sort of work. In other instances pipe is coated and wrapped in central yards situated near the right-of-way of the pipeline.

Protective coatings are not limited to hot enamels. There is a growing use of tapes, plastic tapes made of polyethylene and polyvinylchloride, and coal-tar-coated tapes. Wax-type coatings also are used, and for special applications concrete-type coatings. And, epoxy-resins, which can be sprayed or painted on pipe, are being thoroughly tested.

LOWERING-IN

After the pipe is coated and wrapped it may be lowered into the ditch immediately, or it may be placed on skids for lowering in later.

The lowering-in foreman oversees the delicate task of putting the line to bed in the ditch, and also supervises the making of tie-ins at road and river crossings and at valve settings. When the pipe must be taken off skids and lowered in he will have anywhere from three to six sideboom operators and a crew of swampers.

Using hand signals he quarterbacks the operators as they pick up the pipe and inch it over and into the ditch. The lowering-in chief takes a long look at the ditch before the pipe is set down for the condition of the ditch must please him. If there is insufficient padding, or the ditch isn't deep enough, he'll hold everything until the ditch is right. He will always get as much pipe in as possible, to allow for expansion and contraction.

Once the line is in the ditch, a last inspection ascertains that tie-ins are made, and the fit in the ditch is good. Then begins backfilling.

BACKFILL AND CLEANUP

The operation that pulls the earth back into the ditch, around and over the pipeline, is called backfilling. If the spoil bank contains large, sharp rocks, the coating must be protected before the ditch is backfilled. This can be done by hauling in dirt or sand and filling in next to the pipe before the rest of the ditch is backfilled. It can also be done with a ditch padder that sorts the fine material from the spoil bank and drops it over the pipe. Sometimes a rock shield or padding is used, composed of multiple layers of bituminous-saturated felt bound with a mineral-filled mastic.

Backfilling consists of returning to the ditch the earth that was removed when the ditch was cut, and is done with sideboom tractors equipped with scoops (known as dragline backfillers), or with bulldozers.

With the ditch backfilled, cleanup takes place. Fences must be restored, debris carted off or burned, and any damage off the right-of-way must be repaired to the satisfaction of the landowner. The line, now buried under a clean, neat strip of fresh-turned earth is ready for cleaning internally and testing.

Running the filler bead.

Coating and wrapping.

TESTING THE LINE

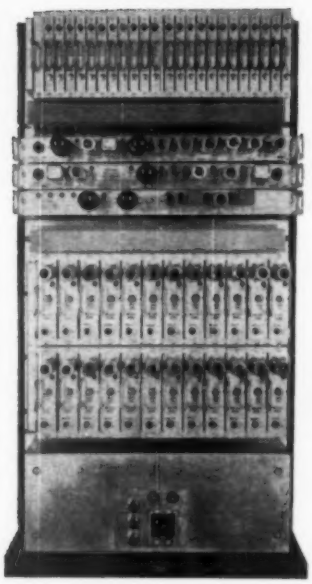
Before the line is tested it is cleaned internally by forcing through it scrapers, called "pigs." Testing is by sections, usually several miles in length. Pressures are applied in excess of what the operating pressure will be, to allow for a margin of safety, by pumping in gas, water, or air. Pressure is left on the line for 24 hr, as a rule, and if there is no drop on the pressure gage, the line is known to be "tight."

If the contractor has done his job well, the pipeline will not be seen again for at least 20 years. To help him achieve this result, every operation is inspected by company inspectors.

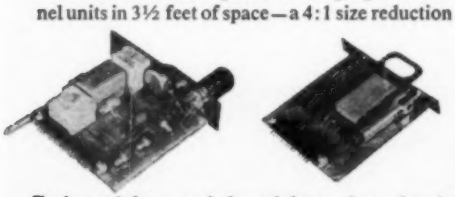
In an age of rockets, satellites, and nuclear weapons, pipeline construction is an easily misunderstood business. You get some pipe, lock it together, dig a ditch, and bury it.

Kellogg Sets New Standards of Reliability in Microwave

Backed by the world-wide technical, manufacturing, installation and operating experience of ITT



New MICROPLEX provides 23 plug-in channel units in 3½ feet of space—a 4:1 size reduction



Each modulator and demodulator channel unit features printed circuitry.

Microwave was pioneered by ITT in 1931 with the Channel crossing from Calais to Dover. Today Kellogg Microwave is achieving new levels of reliability: 99.998%, far superior to wire line systems! Operating in dozens of installations throughout the world, Kellogg's *complete* communications package includes:

- *Microwave* — operating in the 2,000 and 10,000 megacycles bands.
- *Terminating Equipment*—for automating functions, including teletype, telemetering, remote control, data transmission.

Part of the Kellogg 10-C Microwave System is the new 10-C-2 "Microplex": a 23 or 45 channel PTM multiplexing equipment. It features printed circuits, miniaturized components, minimum maintenance, and occupies only three-and-one-half feet of rack space. All demodulators are semi-passive—only one tube per channel; modulators are passive—no tubes. The 23 channels use 41 tubes with an input of 180 watts —a 5:1 reduction in power consumption.

MICROPLEX may also be packaged in one seven-foot rack to provide 45 channels; or 23 channels with two-wire termination and tone signaling. Signal crosstalk is 62 db and signal-to-noise (F1A) is 70 db for 23 channels.

Our engineering staff is always at your service—ready to discuss your communications problems. Write for complete details.

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KELLOGG
CHICAGO, ILLINOIS
Communications Division of ITT

Lowering-in.

Making a tie-in.

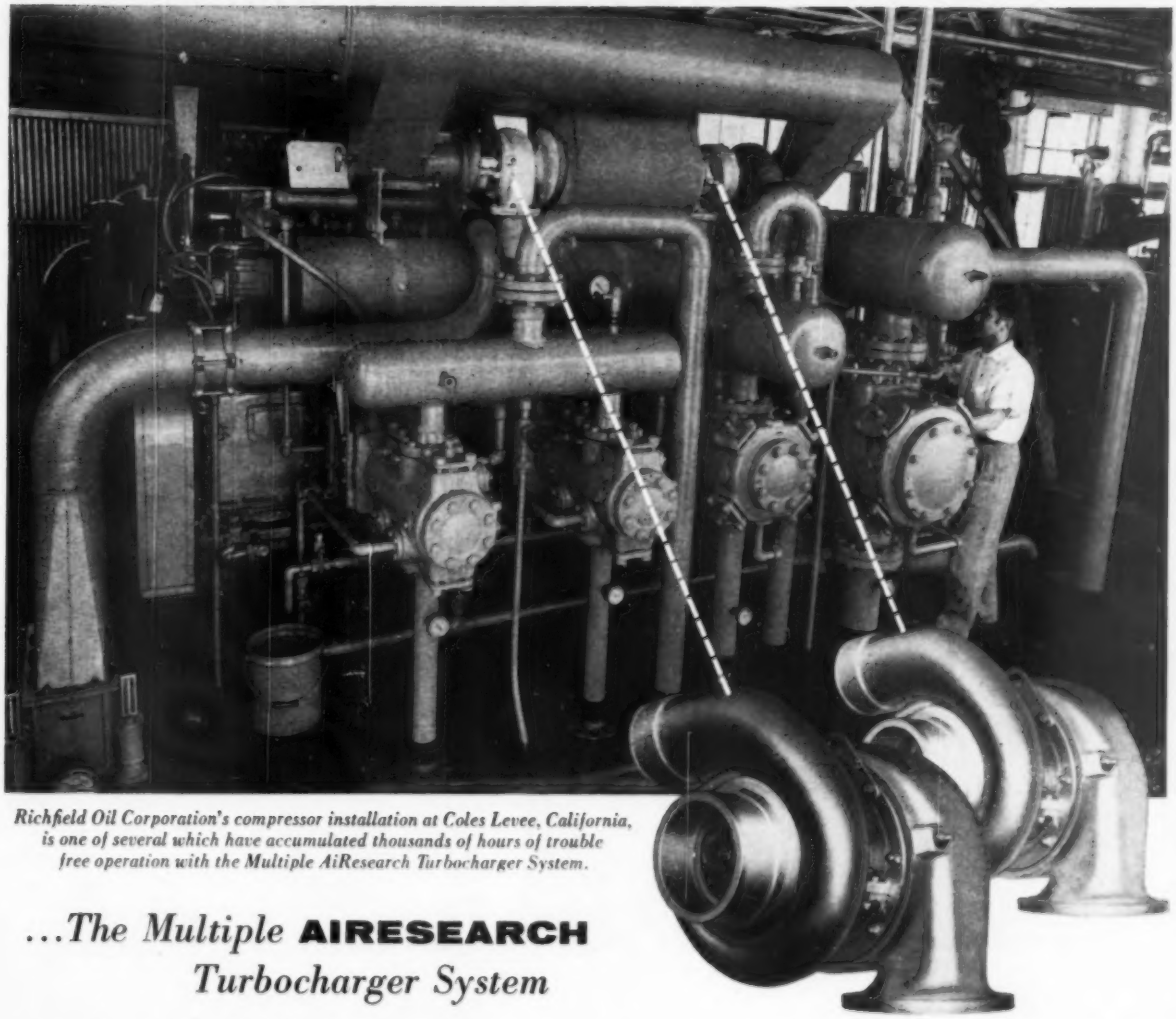
That is the popular conception. It takes only a few days on a spread to realize that this simplicity is a snare and a delusion, for every mile of the way presents new and different problems that must be overcome. Underground springs, quicksand, irate landowners, state regulations, poor housing, unexpected rock, all bring grey hair to the spread man. While the farmer smiles at the rain gently descending on his fields for the seventh day in succession, the spread man grimaces and sets himself to pump and muck the ditch as soon as the sun comes out. Over the 12 to 15 miles of his spread he is called upon continually to make decisions, to improvise, to invent, and ultimately to get the line in the ground, ready for operation before the leaves turn.

Whether he succeeds in this effort depends on a great many other people and situations not discussed in this article. Many people have much to do with the outcome of the construction—the engineering department of the operating company, where design and specifications originated and where responsibility for inspection is lodged; the purchasing department, which sees to it that the pipe and fittings are delivered where and when needed; the land department, whose agents clear legal tangles on the right-of-way, which often surpass the physical tangles, and the transmission department, which cleans, tests and places in service the completed pipeline.

His own logistics and those of his sub-contractors have a direct effect on the contractor's ability to get the job done. And in a highly competitive business like pipelining, getting the job done is more than just a matter of pride and reputation.

Right-of-way cleaned up.

POWER BOOSTING RICHFIELD'S 2-CYCLE GAS COMPRESSORS



Richfield Oil Corporation's compressor installation at Coles Levee, California, is one of several which have accumulated thousands of hours of trouble free operation with the Multiple AiResearch Turbocharger System.

...*The Multiple* **AIRESEARCH** *Turbocharger System*

has helped solve the Richfield Oil Corporation's need for more power to meet increased demands at its compressor stations. Turbocharging the 2-cycle natural gas engines with the Multiple AiResearch Turbocharger System proved to be an economical and quick method for boosting power.

The turbocharger installation is simple and clean. Two production-type AiResearch turbochargers are mounted directly on the exhaust manifold. The compressed air is directed to the engine intake through an AiResearch intercooler. This increases engine output from 300 H.P. to 375 H.P.

AiResearch is a leader in the development and production of air-cooled turbochargers and turbocharger controls for all major diesel engine applications.

Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Industrial Division

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DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

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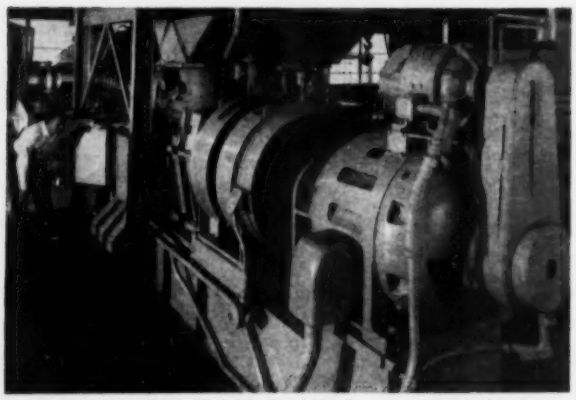
OPERATION upturn
Buy now for extra values
GENERAL ELECTRIC

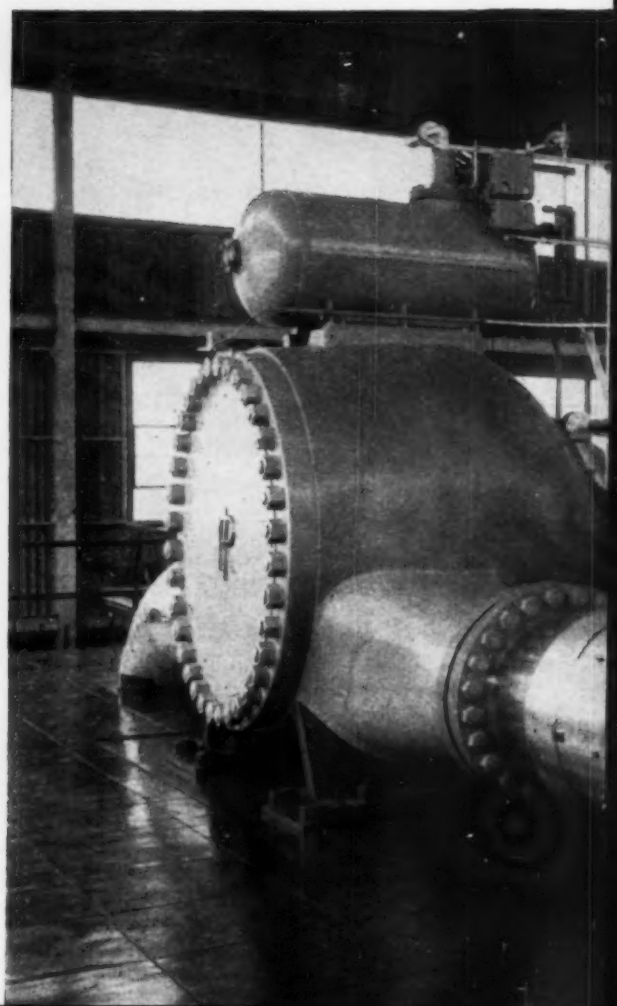
To keep pace with their increasing customer demands, El Paso Natural Gas Company completes 11th pumping station powered by General Electric gas turbine drives

COMPACT GENERAL ELECTRIC GAS TURBINES can provide twice the horsepower of some other prime movers occupying the same floor space. This rotating gas turbine and centrifugal compressor provides smooth, quiet, operation. Installation and maintenance costs are low.

CENTRALIZED Cabinetrol control panels handle practically all auxiliary station functions from one convenient location. Centralized control saves operator time . . . cuts maintenance costs.



DEPENDABLE G-E Tri-Clad* AC Generator provides economical auxiliary power for Belen Station. Improved bearing system gives greater efficiency, longer life, reduced maintenance.



IN 1950, as a part of its continuing expansion program to meet growing demands for gas in the West, El Paso Natural Gas Company began the use of gas turbines for centrifugal compressor drives. The completion of Belen Turbine Station, near Belen, New Mexico, marks a recent step in the realization of their expansion plans.

Belen Station is the 11th EPNG facility to be equipped with General Electric gas turbine drives and centralized control systems. Performance records show that these rugged, compact G-E drives require very little maintenance, and afford substantial floor-space savings.

New, simplified General Electric turbine design eliminates the expense of maintaining a number of auxiliary pumps, blowers and associated equipment. Utilization of either full or semi-automatic control further reduces station operating costs.

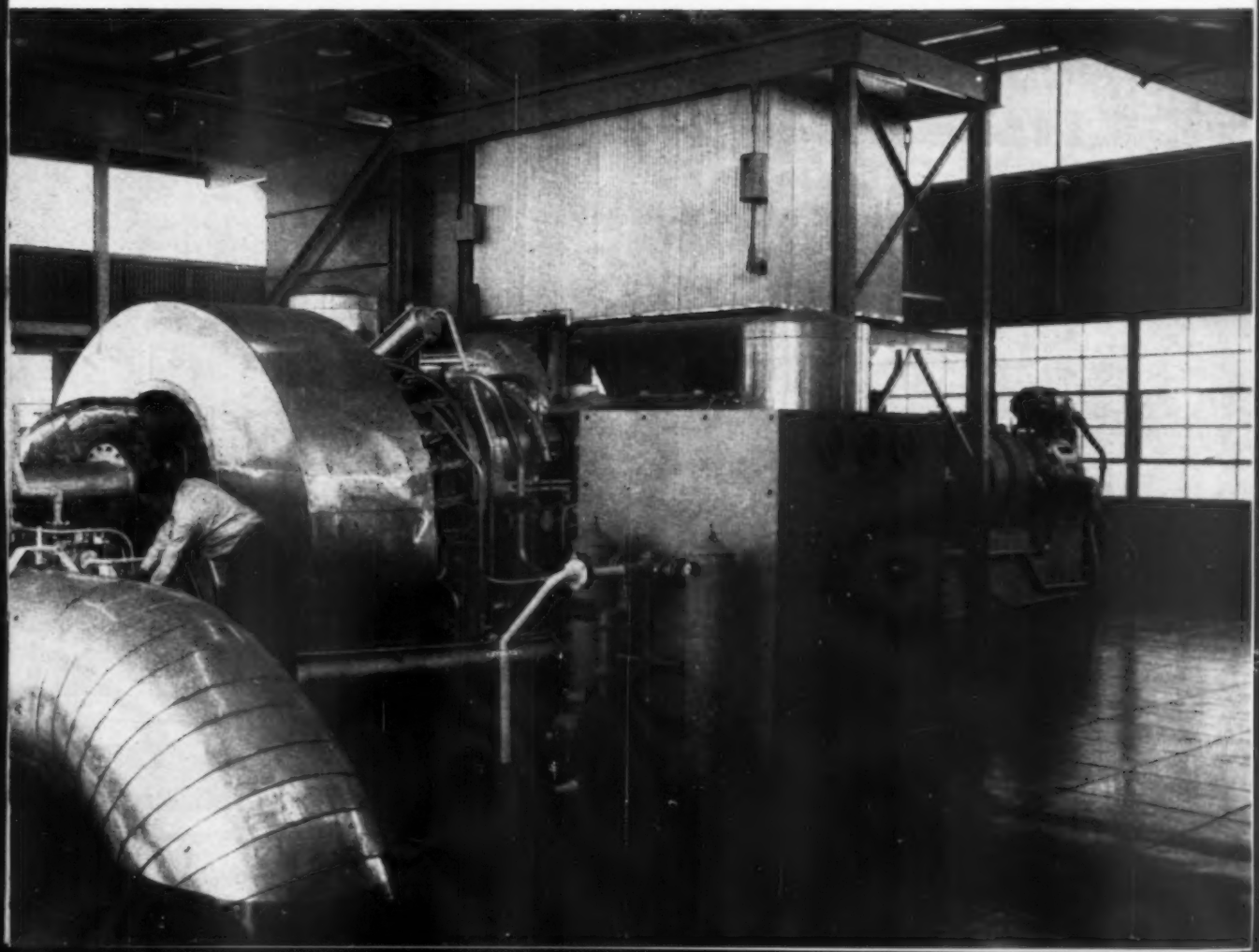
Pre-assembled G-E Cabinetrol* control panels help cut installation costs and centralize operation of auxiliary station functions. Because Cabinetrol control panels can be conveniently located in areas away from operating machinery, no expensive, specially protected equipment is necessary. In addition, the central location of control panels saves operator time and helps provide a neater station appearance.

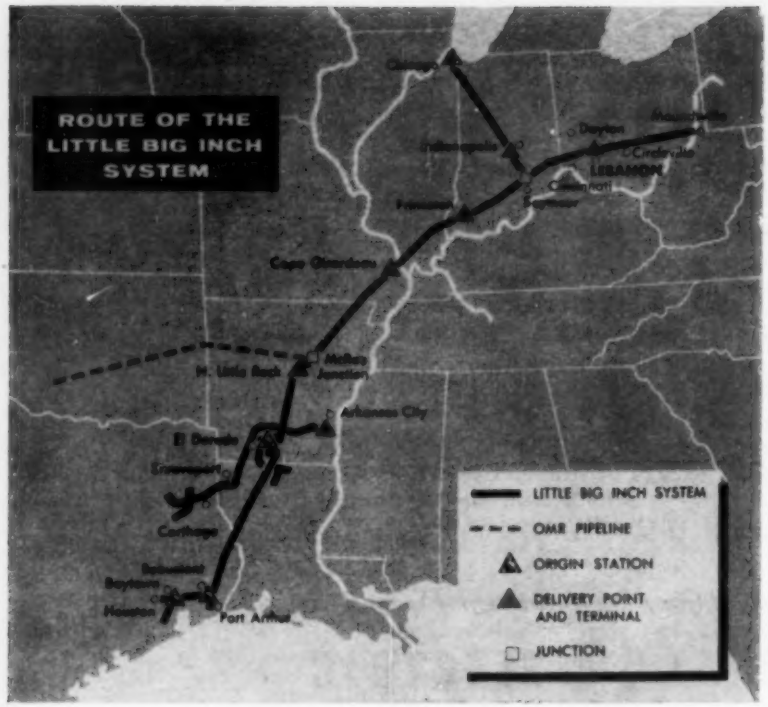
General Electric offers complete engineering service to help you plan the drive system which best meets your gas-pipeline station requirements. Utilization of G-E's experienced system engineering staff can help you get your station in operation faster, with fewer problems, and with less expense. For complete information, contact your nearby General Electric Apparatus Sales Office. For full details on G-E gas turbines, write for free bulletin GED-3546, to General Electric Co., Section 662-51, Schenectady 5, N. Y.

* Reg. Trade-mark of General Electric Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC





DEDICATION OF TERMINAL SIGNALS FULL OPERATION

Little Big Inch

Reconverted to common carrier, complete range of petroleum products will be handled with LPG transportation stressed

Frank H. Love, *Editor*

LITTLE BIG INCH Division of Texas Eastern Transmission Corporation dedicated a terminal at Lebanon, Ohio, last month amid much fanfare, which marks a new milestone for an historical pipeline carrier system emergency-born during World War II.

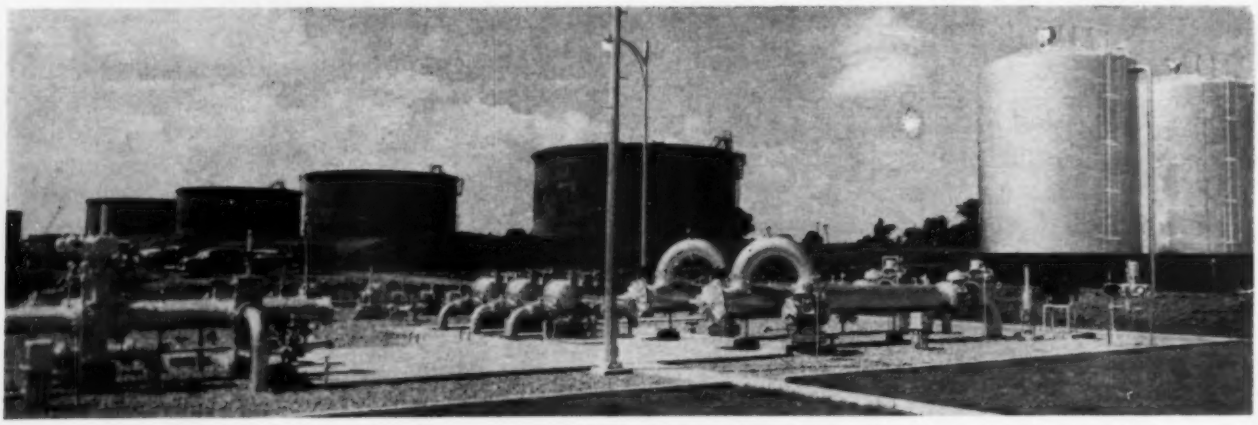
Lebanon is the easternmost terminal on a products system that is the first common carrier pipeline link between Gulf Coast refineries and growing consumer areas of the Midwest.

The system has further significance in that it will give a big boost to transportation of LPG by pipeline. Already a trial shipment of propane has been made from the Gulf Coast to Lebanon, and its successful handling resulted in announcement that top priority would be given to plans to extend LPG transportation to the Eastern Seaboard. Nor should a fact be overlooked that was voiced at the dedication ceremonies by Captain Matthew V. Carson, Jr., director, Office of Oil and Gas, Department of Interior, who pointed out that the Little Big Inch, which once served nobly in a national emergency, would again be available for national defense should the need arise.

The Little Big Inch products system has its origin at Baytown, Texas, near Houston, a few miles inland from the Gulf of Mexico. Its route is northward through Louisiana, Arkansas, and Missouri, then eastward across Illinois, Indiana, and Ohio. A new 14-in. lateral was added last year, between Seymour, Indiana, and Chicago, Illinois, where it will have access to nine terminals owned by other companies. In addition to these terminals and the one at Lebanon, there are Little Big Inch terminals at El Dorado, Arkansas City, and Little Rock, Arkansas; Cape Girardeau, Missouri; Princeton and Indianapolis, Indiana.

Wartime Beginning

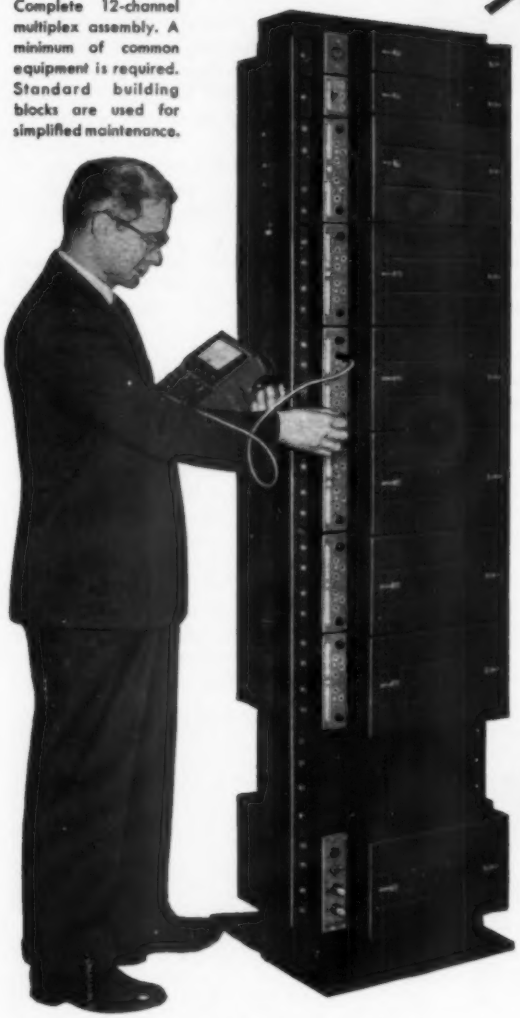
Little Big Inch, which now has approximately 1800 miles of line and 27



Lebanon Terminal, 30 miles northeast of Cincinnati, will be distribution point for wide area in southwestern Ohio.

NOW... Big News in Microwave Multiplex Channeling Equipment!

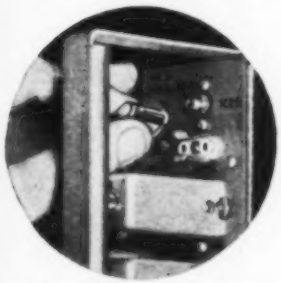
Complete 12-channel multiplex assembly. A minimum of common equipment is required. Standard building blocks are used for simplified maintenance.



RCA Type MV-124 with All Channel Units Identical and Interchangeable

Specifically designed for microwave use, RCA Channeling Equipment provides complete flexibility. Frequency selection is by means of a plug-in crystal. Except for this crystal, *all Channel Units are identical and interchangeable*, thus simplifying planning, installation and maintenance.

Whatever your channeling requirements, MV-124 Multiplex Units can be easily stacked to provide two channels, three channels, or up to 24 voice channels without group modulating. Higher capacity systems can be obtained by stacking 24 channel groups. One unit is required for each voice channel desired. Single sideband suppressed carrier techniques are used to supply 24 channels in the band between 10 kc and 130 kc frequency, leaving frequency space for 18 tone channels below 10 kc. Simultaneous transmission of many channels of intelligence is accomplished by modulating separate sub-carriers spaced uniformly throughout the base-band modulating system. Channels are spaced one above the other in the available modulating band width.



To change channel assignment, simply change one plug-in crystal.

CRYSTAL CONTROL assures high stability and greater accuracy. For operations such as frequency shift telegraph and facsimile transmissions, an unusually high degree of clarity is attained.

DOUBLE HETERODYNING enables all circuits in all units to be identical except for the plug-in crystal element.

SINGLE SIDEBAND OPERATION enables each channel to use a minimum of spectrum space. This means less obsolescence due to possible congestion of the available microwave spectrum.

RCA Microwave . . . performance-proved in more than a million channel miles of operating systems throughout the world.

RCA Microwave Specialists will be glad to answer any questions and help plan your installation. Nation-wide services of the RCA Service Company are provided to keep entire system operating at its peak. Mail coupon for further particulars.

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Millard Neptune, senior vice president of Texas Eastern in charge of products operations, emceed the dedication ceremonies, participated in by many prominent persons.

pump stations in service, has a wartime beginning. At a time during World War II when German submarines were sinking tankers by the score and threatening to completely shut off crude oil supplies to eastern refineries, the government decided that overland pipelines were the only answer. Built under the name of War Emergency Pipelines, Inc., a 24-in. crude oil line was laid from producing fields of the Southwest to the East. A 24-in. pipeline for crude oil transportation was the largest diameter built up to that time and it was understandably called the Big Inch. Soon a companion line for shipment of refined products was constructed of 20-in. pipe and quite logically was named the Little Big Inch.

When the war was over and their need for national defense ended, the government offered these lines for sale. This was in 1946, and the following year they were bought by Texas Eastern Transmission Corporation, an organization formed to bid on the lines. An interesting sidelight is the fact that the cost to build the two lines was $146,000,000 and they were sold for $143,000,000, possibly the only instance of the government not losing its shirt on the sale of war surplus material.

The lines were purchased with the idea of moving gas through them and they were converted to this service. After serving in this capacity for some 10 years Texas Eastern asked the Federal Power Commission for permission to remove the Little Big Inch from gas service so it could be reconverted to a common carrier of petroleum products. Permission was granted in January of this year.

Besides the original Little Big Inch system, and the 14-in. lateral from Seymour to Chicago, what was formerly the Triangle Pipeline Company is a part of the Little Big Inch Division. Texas Eastern purchased Triangle in 1953, a products pipeline serving refining centers in East Texas, North Louisiana, and South Arkansas.

Lebanon Terminal Facilities

Tankage is provided at the Lebanon Terminal for receiving batches of many petroleum products—automotive and aviation fuels, kerosine, heating oils, and various grades of tractor and diesel fuels. A control station is the nerve center for delivering products from the pipeline into terminal tankage through a manifold network.

How the Terminal Operates

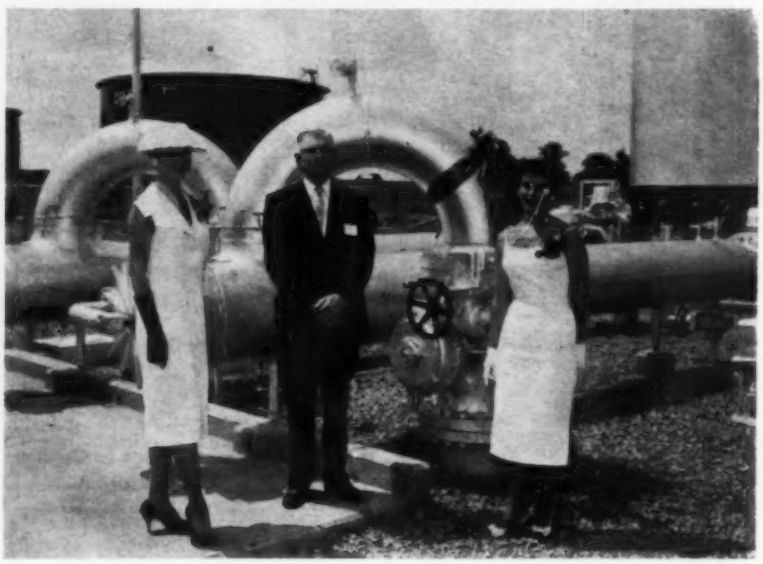
When a shipment of petroleum products is scheduled to be delivered at Lebanon Terminal, the operator is notified by the dispatcher in the general office of the type of shipment, its size, and expected time of arrival. Notification is made over a company-operated teletype network.

Appropriate valves are opened and closed at the terminal to place the tank selected in line to receive the shipment. The valves are lined up just prior to receiving the product in such a way that only one valve need be opened and one closed in order to switch the stream to the next tank. These valves are opened and closed by means of switches on the main instrument panel in the control building.

As the arrival time for the shipment nears, the operator begins watching the readings on a gravitometer on the main instrument panel. This instrument is connected to the Little Big Inch main line, upstream from the main delivery valve. When the gravitometer begins to record a change in liquid gravity, indicating arrival of the expected shipment, the operator opens the main delivery valve by a switch on the instrument panel and the product begins flowing into the selected storage tank.

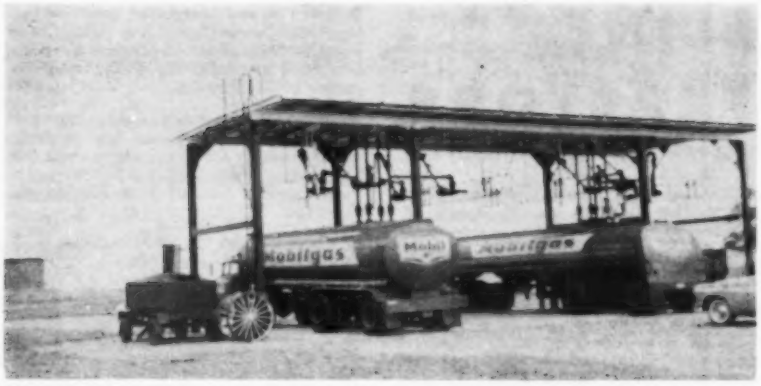
As he opens the main line valve and delivery begins, he records the start of delivery on a printed ticket. The ticket printer is driven by a positive displacement type meter that measures the flow of liquid. When delivery is complete, a second recording is made on the ticket showing the amount of liquid delivered into the storage tank.

If there is to be more than one shipment delivered at the terminal, the operator begins delivery into another storage tank by pressing the appropriate switch on the control panel. A second meter and recorder, provided for such purposes, begins operation as the switch is made, thus tabulating in the same manner the amount of the second shipment. Additional shipments are



H. M. McDonald, vice president and general manager, Little Big Inch Division, Texas Eastern, has just finished turning the valve that began service at the terminal, and is looking quite content. With him are Miss United States (Eurlyne Howell) and Miss Ohio (Peggy Putnam), who also participated in the dedication ceremonies.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Socony Mobil's distribution terminal, which receives its products from the Little Big Inch pipeline.

received by alternately using each meter and recorder to print the delivery tickets for each shipment as it is received.

A special feature of this terminal is the meter proving loop. This is a specially calibrated section of pipe that can be used at any time to prove the accuracy of the delivery meter to assure the shipper that he is receiving into the storage tank the volume of products metered.

To remove products from the storage tanks for distribution, the delivery operator at the loading dock has similar controls, which can open and close the proper valves connecting the right storage tank to the delivery rack. Pumps are started and the product moved from the storage tank to the delivery truck.

Socony Mobil Terminal

Adjacent to Texas Eastern's Little Big Inch property Socony Mobil Oil Company has built a distribution terminal, consisting of four tanks, a control building, and a truck loading rack. These facilities will handle about 45,000,000 gal of petroleum products a year for distribution throughout southwestern Ohio. Shipments will be from the company's refinery at Beaumont, Texas, which has recently undergone an extensive modernization and expansion program.

A shipment of Mobilgas Special from that refinery was the first petroleum product to flow through the Little Big Inch pipeline into the new Lebanon Terminal, and it was delivered to Socony Mobil terminal as a part of the dedication ceremonies. H. M. McDonald, vice president of Texas Eastern and general manager of the Little Big Inch Division, turned the valve to make the delivery, and Walter Guthrie, manager of the Detroit division of Socony Mobil, presented J. W. Hargrove, financial vice president of Texas Eastern, with a check in payment for the shipment.

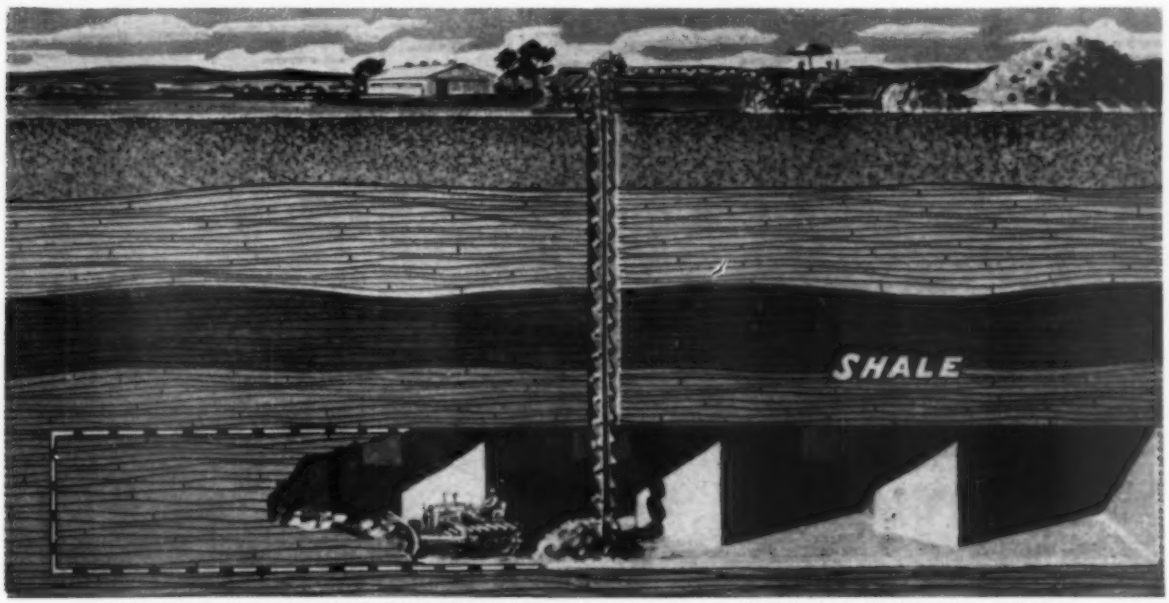
Underground LPG Storage

A few miles from the Lebanon Terminal, just south of Middletown, Ohio, an underground storage cavern for for liquefied petroleum gases is being provided by Texas Eastern. This will be known as the Todhunter Terminal and will have a capacity of 12,000,000 gal of LPG. Later, additional storage capacity will be constructed at the site, which is on an 89-acre tract.

From the Todhunter storage LPG will be distributed by truck and rail throughout a wide range of states from Michigan to New England. It will be brought to the terminal, of course, through the Little Big Inch system.

The Todhunter cavern is being mined from a stratum of gray shale lying about 350 ft beneath the earth's surface. First step in construction was to drill a verticle shaft and cement inside it a 42-in. diam steel casing. Miners then opened a small room at the base of the shaft. A large high-lift bulldozer was dismantled on the surface, lowered piece by piece, and reassembled in this room. Using the bulldozer and specialized mining tools corridors are being tunneled into the shale. The corridors are approximately 15 ft wide and 20 ft high. As the tunnels are made about two-thirds of the shale is left untouched to form walls and pillars and preclude the falling roof or caving sides.

Facilities will be provided at the terminal to refine and filter the LPG before it is loaded into tankcars and tank trucks for shipment, to assure a pure product. * * *



Artist's illustration of how the Todhunter Terminal for underground storage of LPG is being dug by mining methods.
(Drawing by courtesy of Texas Eastern News.)

in 1953, a products pipeline serving

who also participated in the dedication ceremonies.

WITH THE PIPELINE CONTRACTORS

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has contract with *Texas Eastern Transmission Corporation* to furnish field supervision for construction of 626 miles of 30-in. loops along the company's line between Beaumont, Texas, and Uniontown, Pennsylvania. Also 39 miles of 4, 6, and 12-in. in South Louisiana for *Southern Natural Gas Company*. Laying gathering system in Lake Maracaibo, Venezuela, for *Creole Petroleum Corporation*, using concrete coated pipe up to 40 in. diam.

● **Eastern Pipe Line Contractors, 820 Mercantile Building, Dallas, Texas.** Has 79 miles of 10-in. between Quartzsite and Yuma, Arizona, for *El Paso Natural Gas Company*.

● **H. C. Price Co., Price Tower, Bartlesville, Oklahoma.** Laying 133.4 miles of 30-in. loop line in Tennessee and Kentucky for *Texas Eastern Transmission Corporation*.

● **Panama-Williams Corporation, 1418 Melrose Building, Houston 2, Texas.** Has 100 miles of 24-in. from Hughesville, Pennsylvania, to the Delaware River for *Transcontinental Gas Pipe Line Corporation*. Also has 35 miles of 30-in. for the same company between the Delaware River and Princeton, New Jersey.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 212.5 miles 20-in. crude line for *Socony Mobil Oil Company de Venezuela*. Line will extend from San Silvestre field to Puerto Cabello on the Caribbean Coast. Has contract for 42 miles, 24-in. in Louisiana for *Southern Natural Gas Company*. Has contract to build segments of a *Natural Gas Pipeline Company of America* line, consisting of 185 miles of 36-in. in Nebraska and Kansas, and 98 miles of 34-in. in Iowa.

● **O. R. Burden Construction Corporation, Box 5216, Tulsa, Oklahoma.** Has 32.8 miles of 16-in. from Muncie, Indiana, to east of Hollansburg, Ohio, for *Panhandle Eastern Pipe Line Company*. Has 76 miles of 20-in. from Ft. Laramie, Wyoming, to Clendo Junction and from Casper to Welch for *Service Pipe Line Company*. Also has 54 miles of 12-in. to take up and recondition in Goshen, Platte, and Converse counties, Wyoming, for same company. Also has 29.5 miles of 8-in. to raise, recondition and replace between *Service's* Post and Cogdell stations in Garza and Kent counties, Texas. Has 47.7 miles of 12-in. from that company's Salt Creek station in Natrona County, Wyoming, to North Fork station in Johnson County and from Salt Creek to Casper stations. Has contract for gathering system consisting of approximately 84 miles of 4 to 16-in. pipe in Jack and Wise counties, Texas, for *Natural Gas Pipeline Company of America*.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has contract on 7240 ft 30-in. Mississippi River crossing at Happy Jack, Louisiana, for *Tennessee Gas Transmission Company*.

● **R. H. Fulton & Company, Box 1526, Lubbock, Texas.** Has 21 miles of 26-in. from Fritch, Texas, northward, and 205 miles of 36-in. to a point near Meade, Kansas, for *Natural Gas Pipeline Company of America*, and will also build segments of the line from Offerle to Lincoln, Kansas. Has 47 miles of 10, 12, and 16-in. from Erick, Oklahoma, to Shamrock, Texas, and 15 miles of 30-in. in the vicinity of Jal, New Mexico, for *El Paso Natural Gas Company*. Also 50 miles of 30-in. for *Pacific Northwest Pipe Line Company* beginning near Opal, Wyoming, and extending northward to Big Piney, Wyoming. And 61 miles of 16-in. and 15 miles of 20-in. for El Paso Natural in states of New Mexico, Arizona, and Utah.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has 216 miles of 30-in. gas line loops for *Gulf Interstate Gas Company* in Louisiana, Mississippi, and Tennessee. Has 38 miles of 30-in. gas line for *Tennessee Gas Transmission Company* from the Gulf Coast to Yscloskey, southeast of New Orleans, Louisiana. Has Atchafalaya River crossing for *Transcontinental Gas Pipe Line Corporation* just north of Melville, Louisiana, consisting of one 30-in. and one 18-in. line. Has 54 miles of 24-in. natural gas line loops for *Gulf Interstate Gas Company* in the vicinity of Rayne, Louisiana. Has approximately 106 miles of 24-in. gas line for *Southern Natural Gas Company* in Mississippi and Alabama. Has 62 miles of 20-in. crude line for *Shell Pipe Line Corporation* from the vicinity of Nairn, Louisiana, north to Norco refinery above New Orleans.

● **Mannix Company, Ltd., 737 Eighth Avenue West, Calgary, Alberta.** Has 90 miles of 10-in. between North Bay and Sudbury, Ontario, for *Northern Ontario Natural Gas Company, Ltd.* Also has 220,000 ft of 2 to 8-in. distribution lines for same company in Sudbury. Has 20 miles of 2 to 14-in. for *British American Oil Company, Ltd.* consisting of a wet-gas condensate gathering system in the Pincher Creek, Alberta, area. Has 40 miles of 10-in. oil pipeline from Swan Hills field to Fort Assiniboine, Alberta for *Home Oil Company* and *McColl-Frontenac Oil Company*.

"BETTER SWAP IT UP, BOYS, THEY'RE CATCHIN' UP AGAIN!"

● **Arey Pipe and Construction Company, Inc., Box 1501, Pampa, Texas.** Has 105 miles of 6-in. for *West Emerald Pipeline Corporation* between Amarillo, Texas, and Tucumcari, New Mexico.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston, Texas.** Has undetermined amount of gathering system line for *El Paso Natural Gas Company* in the Four Corners area of New Mexico and Colorado.

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has contract with *Saskatchewan Power Corporation* for 124 miles of 10-in. line from Steelman to Regina. Has 40 miles of 10 and 12-in. line for *Home Oil Company* and *McColl-Frontenac Oil Company* from Fort Assiniboine to Edmonton, Alberta. Also 82 miles of 10-in. and 6 miles of 12-in. for *Federated Pipe Line, Ltd.* This is the Southern Schedule of Federated's crude oil line from Swan Hills to Edmonton. Project includes four river crossings, North Saskatchewan, Pembina, Pembina Diversion, and Athabasca.

● **Macco Corporation, 14409 Paramount Blvd., Paramount, California.** Has 20 crews installing and replacing gas pipelines in Southern California area for *Southern California Gas Company* and *Southern Counties Gas Company*.

● **Engineers Limited Pipeline Company, 225 Bush Street, San Francisco 4, California.** Has 102 miles of gathering lines in Aneth field, Utah, for *El Paso Natural Gas Company*.

● **Mid-Mountain Contractors, Inc., 1310 Airport Way, Seattle, Washington.** Has contracted 17 miles of 8-in. between Pasco and Attalia, Washington, for *Cascade Natural Gas Corporation*. Also 9 miles of 4 and 6-in. for *Washington Natural Gas Company* in Kings County, Washington.

● **Banister Construction, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has undetermined amount of 2 to 6-in. extensions to existing systems in cities and towns in Saskatchewan, plus approximately 5000 consumer service connections, for *Saskatchewan Power Corporation*. Has contract for construction of transmission and distribution system in the town of Wilkie, Saskatchewan, for the *Saskatchewan Power Corporation*.

● **H. L. Gentry Construction Company, P. O. Drawer 32, Perrysburg, Ohio.** Has 40 miles of 24-in. between Oneida and Phoenix, New York, for *Niagara Mohawk Power Corporation*.

● **Vaughn & Taylor Construction Company, Inc., Box 3266, Odessa, Texas.** Has 22 miles of 2 to 20-in. waterflood system near Monahans, Texas, for *Gulf Oil Corporation*. Has 20 miles of 4 to 10-in. to take-up and relay on *Pan-American Petroleum Corporation's* gathering system in the South Fullerton field, Andrews County, Texas.

● **Piagott Construction, Ltd, Calgary, Canada.** For *Interprovincial Pipe Line Company*, 82 miles of 24-in. loops in Alberta and Saskatchewan.

● **G. E. T. Construction Company, Inc., 435 South 116th Street, Milwaukee, Wisconsin.** Laying 13.2-mile, 8-in. loop near Fort Madison, Iowa, and 25.3-mile, 12-in. loop near Madison, Wisconsin, for *Michigan-Wisconsin Pipe Line Company*.

● **Western Pipe Line, Inc., P. O. Box 1076, Austin, Texas.** Laying 112 miles of 24-in. and various size pipe in southern Louisiana for *Southern Natural Gas Company*.

(Drawing by courtesy of Texas Eastern News.)

Contractors

● **Oklahoma Pipe Line Constructors, P. O. Box 13227, Dallas 20, Texas.** Has 100 miles of 30-in. for *Creole Petroleum Corporation* between Temblador and Caripito, Venezuela; this is the company's first Venezuelan venture since 1944. Has 96 miles of 30-in. line from Columbus, Mississippi, to Tennessee River for *Tennessee Gas Transmission Company*. (This project to be performed by Oklahoma Contracting Company.)

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has undetermined amount of gathering system for *Producers Pipeline Ltd.* in the Estavan, Saskatchewan, area. Has contract to lay city distribution system in Cooksville, Ontario, for *Consumer Gas Company*. Has city distribution system in Guelph, Ontario, for *Union Gas of Canada*.

● **Trojan Construction Company, Inc., 1416 N. Robinson, Oklahoma City 3, Oklahoma.** Has contract for take-up and reconditioning of 140 miles of 12-in. and 140 miles of 8-in. pipe from Teague to Huffman, Texas, for *Sinclair Pipe Line Company*.

● **Contracting & Material Company, 1235 Dodge Avenue, Evanston, Illinois.** Has 81 miles of 36-in. for *Natural Gas Pipeline Company of America* from Cranston, Iowa, to Sheffield, Illinois. Laying 137 miles of 12-in. from Wood River to Champaign, Illinois, and 112 miles of 12-in. from Champaign to Griffith, Indiana, for *Wabash Pipe Line Company*.

● **Engelking and James, Ltd., Edmonton, Alberta.** Has 88 miles of 14-in., 3.5 miles of 16-in. and a total of 23 miles of various other lines for *Saskatchewan Power Corporation* from and in Success and Hatton gas fields in Saskatchewan.

● **Sharman, Allen, Gay & Taylor, Inc., 3115 Buffalo Drive, Houston, Texas.** Has approximately 28 miles of 30-in. concrete-coated pipe across Lake Borgne in St. Bernard Parish, Louisiana and Hancock County, Mississippi for *Tennessee Gas Transmission Company*. Has 38 miles of 30 and 24-in. for *Humble Oil & Refining Company*, about half of the company's Clear Lake to Port Arthur, Texas, natural gas line, extending from the Hankamer block valve to Port Arthur.

● **Harvey B. White Limited, Box 158, Windsor, Ontario.** Has undetermined amount of 4 to 8-in. distribution lines for *Consumers Gas Company* in cities of Pickering and Whitby, Ontario. Has undetermined amount of 2 to 6-in. distribution lines throughout Windsor, Ontario, for *Union Gas Company*.

● **Clear Span Engineering Company, 4118 Fannin Street, Houston 4, Texas.** Design, fabrication, and construction supervision of 1200-ft. 12-in. overhead crossing of Chesapeake-Delaware Canal for *Eastern Shore Natural Gas Company*.

● **Hunsaker Trucking Contractor, Inc., P. O. Box 97, Carrollton, Texas.** Has contract to string 22 miles of 20-in. for *Lone Star Gas Company* between Trinidad and Corsicana, Texas.

● **Fowler-Tatom Pipeline Contractor, Inc., P. O. Box 368, Cotton Valley, Louisiana.** Laying 27 miles of 20-in. for *Southern Natural Gas Company* from White Castle, Louisiana, to the east bank of the Atchafalaya Basin levee, and from the west bank of this levee to a point near St. Martinsville, Louisiana.

● **Latex Construction Company of Georgia, P. O. Box 12128, Atlanta 5, Georgia.** Has 22 miles of 14-in. for *Southern Natural Gas Company* from Bell Mills, Alabama, and Cedartown, Georgia, and 41 miles of 14-in. for same company between Macon and Griffin, Georgia.

Mannix Company Makes Executive Appointments

Mannix Company, Ltd., Calgary, Alberta, Canada, announces several new executive appointments.

T. C. Oxmen, who has been manager of the Highways Division of the company, has been appointed vice president and manager of operations.

E. P. Lougheed, secretary and general counsel, has been appointed vice president of administration and a director of the company.

C. P. Baker, formerly Pacific area representative of Vancouver, has been made manager of the general contracts division.

Interstate to Connect Mississippi Fields

Interstate Oil Pipe Line Company has announced plans for a 35-mile extension of the trunk line system in its Brookhaven, Mississippi, district.

The extension will provide pipeline service to the recently discovered Raleigh, Martinville, and Magee fields in Simpson and Smith counties, Mississippi. Transportation of the oil from these fields at present necessitates truck movement to Gwinville, Mississippi, where the oil is delivered into Interstate's existing system.

News

Irish Engineering Service of Shreveport, Louisiana, has been awarded a contract for reconditioning and coating the necessary pipe, which will be of 6-in. and 8-in. diam. A contract for construction of the line is to be awarded in the near future. It is expected that construction will be completed by the end of the year.

The pipeline extension will connect with Interstate's present Mississippi system near Gwinville.

Southwestern Saskatchewan Oil Movement Shows Increase

Oil flow from southeastern Saskatchewan has been well sustained through the summer, and throughput in the Westspur pipeline in July reached a new high of 85,155 bbl per day average, an increase of 12,620 bbl per day over June and substantially above the previous high mark of 81,822 bbl per day recorded in February.

Westspur Pipe Line Company reported average deliveries of 77,310 bbl per day in the first four months of 1958, showed a start of recovery in May with 69,932 bbl per day, above the April low point, and continued to increase deliveries through July. The August estimate, however, was 80,975 bbl per day, a moderate decline of 4180 bbl per day from July.

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Pipeline Projects

Transco Gets Approval, Swings Into Action

Transcontinental Gas Pipe Line Corporation expects to meet its commitments for increased deliveries of natural gas this winter to the New York City-New Jersey-Philadelphia metropolitan area and to customers in the South, E. Clyde McGraw, Transco president, announced when notified that the Federal Power Commission had issued a certificate to permit construction to render this service.

Heavy equipment and men swung into action immediately. Contracts on key phases of the extensive program had been let months earlier. Men and materials were at construction sites along the Eastern Seaboard and in the Deep South.

Faced with commitments for increased allocations this winter but without authority to start construction, Transco had purchased the necessary pipe and moved it to temporary pipeyards along the system. Contractors made arrangements to have pipeliners and machines at construction sites.

When notice of the FPC certificate came Transco gave the contractors the go-ahead.

Completion of Transco's current construction programs will complete looping of the Transco system from the natural gas supply areas of the Gulf Coast all the way to the New York City area. Previous construction programs through the years had looped the system except in separate stretches totaling some 232 miles between Eunice, Louisiana, and Princeton, N. J.

In the New York City-New Jersey-Philadelphia metropolitan area alone, Transco has commitments this winter for an increase in daily allocations of 190,000,000 cu ft of natural gas. This area already has present daily allocations of 669,000,000 cu ft plus 136,000,000 on peak days from Transco's present storage. For the entire Transco system including the South, plans call for an increase in daily allocated capacity from 953,000,000 cu ft to 1,191,000,000 plus an increase from 136,000,000 to 340,000,000 cu ft per day of storage capacity.

The Transco $167,000,000 program includes laying loop lines of 204 miles of 36-in. and 106 miles of 30-in. pipe in 10 states. Another key phase of the program is a 24-in. purchase lateral in Louisiana extending south from the Louisiana-Mississippi State border to cross under the Mississippi River and then branch into lesser laterals to new gas reserves both onshore and offshore.

To move the increased quantities of natural gas, other contractors began installing additional horsepower at existing compressor stations. New stations to be built are not yet underway.

Construction of the 192 miles of 24-in. and 30-in. line from the main line system in New Jersey to the Leidy storage field in north central Pennsylvania also began. This line will enable Transco to more than double the amount of storage gas it can supply the metropolitan area by the winter of 1959-1960.

Tennessee Withdraws Station Application

The Federal Power Commission has issued an order permitting Tennessee Gas Transmission Company to withdraw its application seeking authority to construct a 6000-hp compressor station in Pennsylvania to enable it to increase storage service to two of its customers.

Tennessee filed a withdrawal request stating that the agreements under which it proposed to render the service for which it had sought authorization, had been canceled at the request of the proposed customers—The Brooklyn Union Gas Company, and Consolidated Edison Company.

FPC, in June, granted Tennessee temporary authority to construct and operate the proposed station but it was never accepted by Tennessee.

El Paso Given Final Approval for Pipeline

The Federal Power Commission has granted El Paso Natural Gas Company authorization to construct and operate facilities, estimated to cost about $946,000, to enable it to purchase residue gas in Pecos County, Texas.

In its application, El Paso proposed to construct about 21.4 miles of 10¾-in. pipeline extending from the Santa Rosa Gas Company's proposed Fort Stockton compressor station to the Pecos company's existing processing plant, all in Pecos County; about 18.4 miles of 8⅝-in. line from the Pecos plant to a point in Ward County, and additional metering facilities at the Pecos processing plant.

FPC in December 1957 granted El Paso temporary authorization to construct and operate the facilities.

Ready to Begin Construction Of Algerian Crude Oil Line

The United States Embassy in Paris reports that construction is ready to begin on a 24-in., 480-mile crude oil pipeline from the Hassi-Messaoud field, Algeria, to the port of Bougie on the Mediterranean Coast. The line will be built by the government-controlled Societe Petroliere de Gorence and will replace an existing 4-in. line from the field that now extends only as far as the railhead at Touggourt.

Completion of the pipeline is scheduled for October 1959, with initial capacity of 4,000,000 metric tons a year. Plans are for the capacity to be increased to 10,000,000 metric tons by 1962, and 14,000,000 tons by 1964.

In line with the declared policy of promoting more processing activities within Algeria itself, construction will begin soon on a new refinery to handle a part of the Hassi-Messaoud crude, it was also announced. Companies participating in this project will be Standard of New Jersey, Mobil, Beryl-Algeria, Shell of Algeria, British Petroleum, and Compagnie Francaise des Petroles. The refinery will be located 6 miles southwest of Algiers, and will process about half of the pipeline's initial annual capacity. The remainder will be exported to France. Bougie port will be developed to handle the export load.

Communists Say Pipeline Will Link Russia, Satellites

A major oil pipeline system linking Russia and her European satellites is slated for construction in the early 1960's, according to an official East German government report.

The pipeline project is said to be necessary because of rapidly-rising oil consumption in Communist Europe. East Germany alone expects its oil imports to increase from about 1.5 million metric tons in 1960 to 4.8 million tons in 1965. A "large" new East German refinery will also be built in the early 1960's, it was stated.

Romania Is Extending Pipeline Facilities

Transmission facilities are being extended in Romania. A trunk line serving Bucharest is operating, and three other major links are being built.

The so-called "northern" line will be extended into Hungary. The "western" line will soon supply the iron and steel mills at Hunedoara. An "eastern" line will serve the Moldova industrial district.

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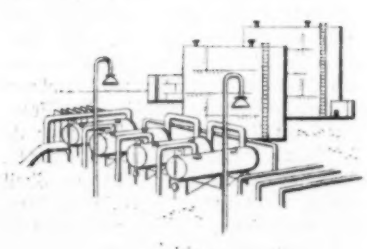

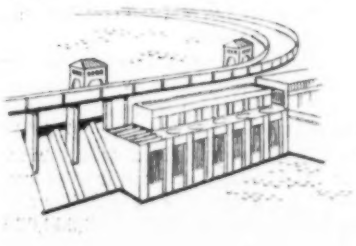

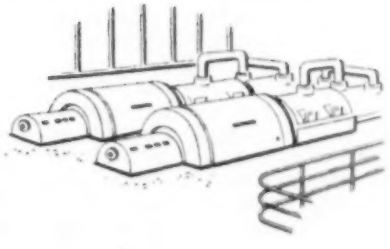

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Projects

Swan Hills Lines Scheduled For November Completion

The Swan Hills job of Mannix Company, Ltd., which includes 40 miles of 10-in. through the soft muskeg terrain from the Swan Hills oil producing area to Fort Assiniboine, on the route to Edmonton, is in process of clearing and grading right-of-way. The scheduled completion date is November 1. Federated Pipe Lines, Ltd., is the owner. R. Telford is spread superintendent. With all other contracts completed ahead of schedule, Fulton-Banister, Ltd., has had a main line spread at work since the middle of August on the southern portion of the Swan Hills crude oil pipeline for Federated Pipe Lines, Ltd. The job consists of 82 miles of 10-in. and 6 miles of 12-in. Construction started at the southern end of the line, in the East Edmonton refinery area, and the first field office was set up at 96th Street and 132nd Avenue in the northeast section of Edmonton. George Caron is spread superintendent and Lou Tolliver assistant.

Four major river crossings are being laid by a separate crew under supervision of Bill Bolt. North Saskatchewan and Athabasca are the widest crossings, others are the Pembina and Pembina Diversion. Completion is scheduled for November 1.

Texas Gas to Lay Loop In South Louisiana

Texas Gas Transmission Corporation has been authorized to construct and operate natural gas facilities in Jefferson Davis and Acadia parishes, Louisiana, at an estimated cost of about $725,500.

Texas Gas will construct approximately 12.5 miles of 16-in. loop line from the Lake Arthur field, Jefferson Davis Parish, to a point of interconnection with its 26-in. Eunice-Bastrop pipeline near Eunice, Louisiana.

Maximum capacity of the line, with the proposed loop, will be 344,400,000 cu ft, an increase of 128,400,000 cu ft over existing capacity.

First Part of Southern Natural's Program Approved

The Federal Power Commission has granted Southern Natural Gas Company temporary authority to construct facilities in Louisiana, Mississippi, Alabama, and Georgia, at an estimated cost of about $28,717,530.

Authorized for construction were 224 miles of 24-in. main line loops; 46 miles of 20-in. loops; 40 miles of 14-in. loops; approximately 53 miles of various diameter branch line loops; four 16-in. river crossings, totaling about 2.6 miles; 9 miles of field lateral lines; 124 hp in additional compressor capacity, and 2 metering stations.

Southern Natural's application proposes over a 2½ year period the construction of 461 miles of 16 to 24-in. main line loops; 62 miles of 14-in. branch lines; 53 miles of various diameter branch lines; 212 miles of field lines; 12,254 hp in additional compressor capacity; 12 river crossings; 8 purchase meter stations, and appurtenant facilities. The cost of the entire project is about $64,458,670. The additional facilities will enable Southern Natural to increase its system capacity by about 380,000,000 cu ft daily to meet its estimated 1960-61 peak day requirements and would enable it to attach additional supplies in several fields.

El Paso Granted Authority For Part of Proposal

The Federal Power Commission has granted El Paso Natural Gas Company temporary authority to construct and operate facilities to enable it to acquire natural gas from the Aneth field area of Utah, Colorado, New Mexico, and Arizona.

Proposed is the construction of approximately 13.3 miles of 20-in. and 62.6 miles of 16-in. transmission line; about 102.3 miles of various diameter field lines; a 30,600-hp compressor station; gasoline, fractionating and dehydration plants; wells for its own production, and various metering facilities, river crossings, and appurtenant facilities. The facilities would be constructed over a four-year period and cost an estimated $26,085,000.

FPC granted temporary authorization for that portion proposed for construction in 1958, consisting mainly of 20 and 16-in. pipeline and the compressor station with 10,200 hp.

Finish Gas Line From Carbon Field to Calgary

Crews of Canadian Western Natural Gas Company, Ltd., have completed the 16-in. natural gas pipeline from the Carbon field to Calgary, a distance of 58.5 miles. Construction started at South Calgary, at the city gate, and the line was welded and doped out at a point four miles east of Carbon, near Sharples. Accommodation was provided throughout the job in a portable tent and trailer camp, due to lack of public accommodation in the unpopulated area through which the right-of-way runs. Two moves were made in the course of the work.

Construction is proceeding on the field gathering system, which initially will tie in six company-owned wells in the Carbon field to provide 50,000,000 cu ft per day peak load deliverability for the Calgary city distribution system. Ultimately more wells will be tied in, for maximum flow of 150,000,000 cu ft per day.

Permian Basin Line Awaits FPC Approval

Permian Basin Pipeline Company proposes 61 miles of 16-in. and 11 miles of field lines to take gas from the Emperor field, Winkler County, Texas. The project is awaiting FPC approval.

Coastal States Gas Plans 250-Mile South Texas System

Coastal States Gas Producing Company is planning to build approximately 250 miles of pipeline in South Texas to fulfill commitments made to two transmission lines. Recently Coastal States signed letters of intent to deliver a minimum of 195,000,000 cu ft of gas a day to Transcontinental Gas Pipe Line Corporation and Texas Illinois Natural Gas Pipeline Company for a period of 20 years.

To fulfill these contracts, Oscar S. Wyatt, Jr., chairman of the board and president of Coastal, says his company will spend $12,000,000, to add to its facilities 250 miles of 18 and 20-in. main lines and 14-in. laterals. The new system initially will serve seven counties in South Texas, with possibility of extensions through three other counties. It will connect with five of Coastal's existing gathering systems.

Uncompressed capacity of such a system will be approximately 280,000,000 cu ft a day; with compression the delivery rate will be about 500,000,000 cu ft a day.

New Organization Takes Over European Line Plans

Societe du Pipeline Sud-Europeen has been organized in Paris to make engineering plans for construction of the long-contemplated pipeline from Marseilles to the Upper Rhine. The new company was formed by a group of international oil firms who will participate in the pipelines system, which will supply crude to French and German refineries to be erected in the area of Strasbourg-Karlsruhe. Another company, known as Sopimer, was created in the summer of 1956 for this purpose, and is now being replaced by the new firm.

Eighteen companies will participate equally in the Société du Pipeline Sud-Européen, as follows: Deutsche Erdoel AG., Gelsenberg Benzin AG., Mobil Oil AG. in Germany, Scholven-Chemie AG. and Wintershall AG., Antar Pétroles de L'Atlantique, Soc. Française des Pétroles BP, British Petroleum Company, Caltex S.A.F., Cie. Française des Petroles, Cie. Française de Raffinage, Pechelbronn S.A.E.M., Petrofina S.A., Purfina Française, Shell Berre, Bataafsche Petroleum Mij., Mobil Oil Française S.A., and Standard Oil Company (New Jersey).

PIPELINE PERSONALS

Robert R. Herring, president of Fish Service Corporation, was recently elected to membership in the Young Presidents' Organization. He will participate in the National as well as the Southeast Texas chapter. Founded in 1950, YPO has almost 1200 members. A graduate of Texas A & M, and Georgetown University in Washington, D. C., he became assistant to the president of Fish Engineering in 1950, and in 1952 he was elected president.

R. R. Herring

J. S. Bullington

J. S. Bullington has joined Northern Natural Gas Company as senior industrial representative in the department of marketing, economic research and area development. He was director of the industrial development division of the Oklahoma State Department of Commerce and Industry for three and one-half years prior to accepting the position with Northern.

Kenneth N. Hostler has been promoted to chief engineer at the Ohio Fuel Gas Company's Weaver compressor station near Lucas, Ohio. Hostler succeeds **Merlin M. McInturf** who was named southern compressor division superintendent. Hostler has been with Ohio Fuel 22 years.

James Neill Fuquay has been named chief engineer for Sun Pipe Line Company's department at Beaumont, Texas. He replaces **J. B. Turner,** who recently transferred to Venezuelan Sun Oil Company. Fuquay joined Sun as a civil engineer in 1948, and in 1956 was named assistant chief engineer, a position he held until his recent promotion.

Two other appointments were **Edgar Miller Jr.** and **Wallace A. Robinson** who were named senior engineers, newly created positions, in the Beaumont office. Miller was formerly assistant chief gager, having been with the company since 1948. Robinson, who went with Sun in 1949, is former mechanical engineer in Beaumont.

H. M. Karr has been appointed to the newly created position of manager-technology in Shell Pipe Line Corporation's head offices in Houston. He was formerly assistant manager of Shell Oil Company's manufacturing organization engineering department in New York.

Ted Gupton is new management engineer for Pipe Line Technologists, Inc., Houston, Texas. He recently retired from Alco Products, Inc. as district sales manager in charge of Alco's Houston office. He is an engineering graduate of Washington University, St. Louis, Missouri.

J. C. Yow, who has been employee relations manager of Plantation Pipe Line Company since it was started in 1941, has been selected as security administrator for the company to handle its civilian and disaster programs. **H. H. Long** has been selected as employee relations manager to replace Yow. Long has been assistant employee relations manager since 1952 and has been with Plantation since 1947.

Hans C. Jensen, Pittsburgh, Pennsylvania, has been appointed as petroleum transportation and storage specialist in the Interior Department's office of Oil and Gas. He succeeds **Earl Ellerbrake,** resigned. Jensen has been employed by Gulf Oil since 1947, and director of transportation planning and programming since 1956.

Ned Nyberg, associated for the past 12 years with Hill Equipment Company of St. Louis, Missouri, in welding sales, has opened an office as a welding consultant, specializing in fabrication practices, production mechanization and wear control in maintenance. Nyberg attended Oklahoma A & M College (now Oklahoma State University).

C. A. Cone

Charles A. Cone has been named president of the recently organized Oil States Engineering Company, Tulsa, Okkahoma. He was former vice president of Dresser Engineering Company. Oil States designs and erects pumping stations, gas compressor stations, and gas products plants. **W. G. Storey** formerly with Trend Construction Company, is vice president of the company. **A. C. Young,** secretary-treasurer of Oil States, was formerly with Dresser. Cone received his BS degree from the University of Oklahoma.

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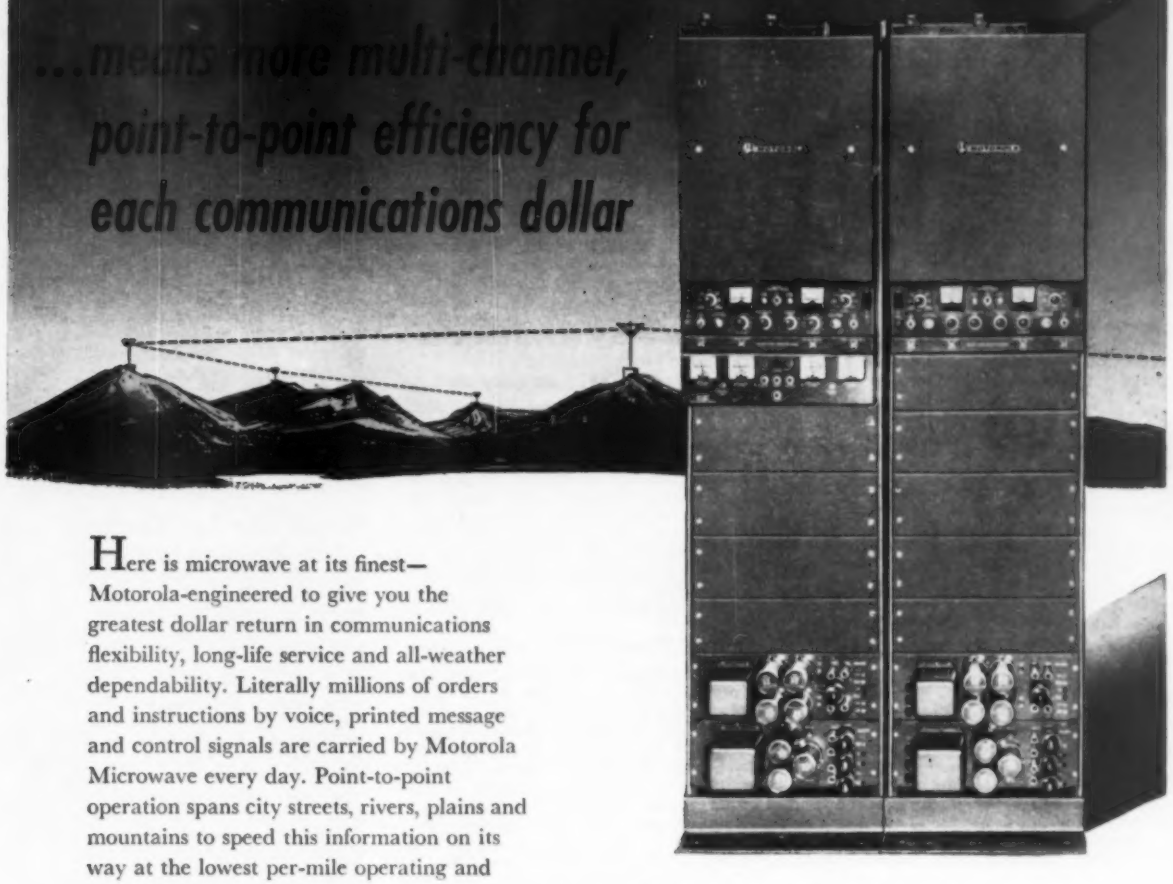

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It's New Pipeline Equipment

Transistorized Mobile Radio

A gigantic step toward a completely transistorized two-way mobile radio has been achieved by Motorola in its new

Motrac radiophone. The compact, futuristically styled Motrac radio, now being given operational field tests, has completely transistorized receiver and power supply and a partially transistorized transmitter.

More than 20 transistors are utilized to provide the Motrac radiophone with reliability standards and current drain characteristics.

Printed circuitry, modules and die cast construction are employed throughout the unit to further its reliability, compactness, and ruggedness. Entire unit is 3 in. high, 11 in. wide, and 17 in. long.

Primary advantage of the Motrac unit is its low power consumption characteristics. The complete unit draws only 1.82 amp while on standby — that is, just turned on waiting to hear a message, a condition in effect 99 percent of the time. *Motorola, Inc.*

Circle number (81) on reply card.

Portable Process Mixers

A new line of Jensen portable process mixers is designed to meet highly critical operating conditions. These mixers feature a new design clamp using a worm-gear adjustment that eliminates possibility of tank damage or batch loss. Units are also available for fixed mounting on either open or closed tanks. *Jensen Engineering Company.*

Circle number (82) on reply card.

Tractor "Splitting" Tool

A simple means of "splitting" the Euclid TC-12 twin-engine tractor, by pushing the pivot shaft out of its housing with hydraulic power, has been developed by the Owatonna Tool Company. This new tool utilizes an OTC 50 ton power-twin ram and forcing screw for power. By removing the cover plate, retainer caps, and other retaining parts, mounting the tool in existing cover bolt holes and applying pressure, the job of splitting the mammoth tractor for over-the-road transportation is accomplished in a fraction of the time normally required. *Owatonna Tool Company.*

Circle number (83) on reply card.

Better Tractor Efficiency

Introduction of several new attachments designed to extend the working efficiency and ease of operation of the D4 and D6 tractors has been announced by Caterpillar. In-seat starting, which allows all engine starting operations to be performed from the operator's compartment, is a newly-available attachment for the D4. With all starting controls mounted on the dash, the operator is able to start the gasoline starting engine without leaving the seat. For both D4 and D6 tractors operating with front-mounted hydraulic equipment in atmospheric temperature over 100 F, a high ambient temperature radiator is available as an attachment. The new radiator is recommended for use only if overheating problems occur due to a combination of both of the above factors.

Another attachment, designed to allow these tractors to operate a full day without refueling, has been made available. The D4 attachment, a 45-gal fuel tank, allows the tractor to operate 50 percent longer between refueling stops than with the standard 30-gal tank. The large capacity fuel tank for the D6 is rated at 60 gal, an increase in size of 25 percent over the standard 48 gal tank. *Caterpillar Tractor Company.*

Circle number (84) on reply card.

Hobart PowrWeld

The new Hobart "PowrWeld" unit is a combination d-c arc welder of 200-amp capacity and an a-c power unit of 5 kw capacity. It is different from previous models of combination arc welder and power units, in that it provides d-c welding current (for either straight or reverse polarity electrodes) instead of a-c welding current with the a-c power. Also, a-c power can be drawn from the unit for lights and tools at the same time it is being used for d-c welding. The d-c welding generator is rated 200 amp, at 25 v, on 100 percent duty cycle, and has a welding range of 30 to 225 amp for intermittent use. *Hobart Brothers Company.*

Circle number (85) on reply card.

Cylinder Pressures Measured

SLM Spark Plug-Pressure Gage Combination provides continuous, accurate measurements of compression and firing pressures in internal combustion engines. There is no modification of the combustion chamber, or use of special spark plugs that may alter the combustion process.

Rugged enough to withstand and indicate detonation and other destructive types of abnormal combustion, this indicator offers advanced instrumentation for engineering evaluation, production test, field maintenance, and fuel octane rating on both slow and high speed internal combustion engines.

Based on a new and unusual design approach, the combination employs a separate subminiature quartz gage mounted in any standard spark plug. *Kistler Instrument Corporation.*

Circle number (86) on reply card.

Longer Microwave Hops

A 2000-mc power package has been developed that enables microwave users to reduce costs for repeater equipment by putting longer hops in their systems. The new package includes a power amplifier, power supply, cables, and other equipment necessary to increase the power output of the main transmitter in a microwave system to as high as 80 watts. In systems where a 20-watt transmitter previously was used, this could mean an improvement of 6 db in gain, effectively increasing the total distance one hop will cover. G-E engineers point out that, in many instances, distances of more than 100 miles will be easily obtained with the gain made possible by the new unit. The new power amplifier will be especially beneficial in instances where mountainous terrain is involved, because it reduces the number of points at which equipment must be installed. *General Electric Communication Products Department.*

Circle number (87) on reply card.

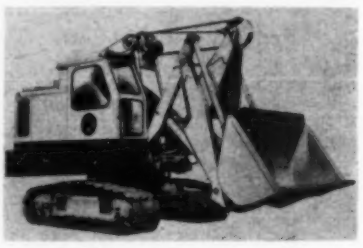
Winch Line Tail Chains

Primarily intended for use on truck and tractor winch lines, these winch line tail chains are equally adaptable for use on any wire where the addition of a flexible end member will add to the usefulness of the rope. They have been designed to eliminate the difficulties usually encountered under severe operating conditions such as wrapping wire rope around machinery for lifting, loading, hauling, or skidding. A new hook has been designed that has high strength and gives a secure hold without injury to the rope. The chain itself is electrically welded from high carbon steel and has machine-formed short links. Ultimate breaking strain is approximately twice that of ordinary chain. *American Chain & Cable Company, Inc.*

Circle number (88) on reply card.

Koehring "Skooper"

The "Skooper," offering a new concept in speed loading, has been introduced by Koehring. By utilizing the fast swing of an excavator turntable and a 7-ft independent crowding action, the "Skooper" can go through numerous complete loading



cycles while standing in one place. Job condition tests have shown the "Skooper," operated with 70 hp, can load 400 tons per hr. This amounts to 5.7 tons for each hp hr. *Koehring Company.*

Circle number (89) on reply card.

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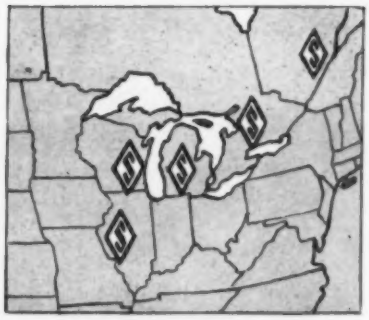

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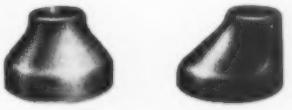

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Air-Cooled Welders

New drooping-voltage arc welders are now available from Air Reduction in three types—250-amp d-c, 300-amp a-c/d-c, and 300-amp a-c/d-c Heliwelder. All machines provide 115/230-v, 10-kw, single-phase, 60-cycle power when operated as power plants. They have 115-v,

1-kw d-c auxiliary power available for operating lights and power tools while welding.

The 250-amp d-c machine is designed for general purpose construction and maintenance welding in the field, especially pipeline work. The 300-amp a-c/d-c machine is a remote area welder and power plant for a-c welding and d-c reverse or d-c straight polarity welding current. The 300-amp a-c/d-c Heliwelder is for field operations where aluminum or magnesium structural welding is involved. *Air Reduction Sales Company.*

Circle number (90) on reply card.

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Tube type totally enclosed fan-cooled squirrel-cage motors are offered in polyphase ratings through 500 hp by Wagner Electric. Efficient cooling is provided in these fabricated steel frame motors by a series of tubes through which outside air is forced by an external blower. An internal blower at each end of the rotor circulates the warm air inside the motor through ducts in the rotor and stator and around the cooling tubes, to hold the temperature rise within the specified limit. *Wagner Electric Corporation.*

Circle number (91) on reply card.

Fabric Pipe Coupling

A product for making permanent cement couplings on multi-duct concrete, clay, or tile pipes and conduit is designated Permacel 55 Cement Bandage. The product is a cotton fabric impregnated with a Portland cement composition and is available in a variety of widths, lengths, and in a number of layers of fabric. *Permacel.*

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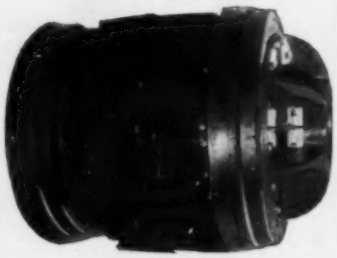

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New Equipment

PD Pearson Type Detector

Development of a Pearson type detector for pipeline inspection and location is announced. The Model PD Pearson detector is useful for three types of work. It can locate discontinuities in protective pipe coating down to minute perforations of the wrappings in pipe buried at normal depths and can locate these "holidays" from the surface of the ground and without uncovering the pipe. It can locate electrical shorting between two pipelines or between a pipeline and some other metal structure. And, it can trace an individual pipeline including its branches, through a maze of buried pipe in city streets when the systems are not electrically connected. *Tinker & Rasor.*

Circle number (94) on reply card.

Pipe Cutters

A new line of pipe cutters, designed to give cleaner, straighter cuts than ever before, is now in production. A new form-fitting handle, designed to fit the hand, and the sturdy malleable frame, are said to lengthen the life of these new cutters. Other improvements include a new high-alloy steel cutting wheel, new sliding block construction, new replaceable slide plate, and a longer shank to protect the threads. These cutters are available in four models: No. 10, ⅛ to 1¼ in.; No. 20, ⅛ to 2 in.; No. 201, ⅛ to 1¼ in.; and No. 202, ⅛ to 2 in. No. 201 and No. 202 have extra-wide rollers and can be used by hand or with power. *The Toledo Pipe Threading Machine Company.*

Circle number (95) on reply card.

Tractor Shoe "Work-Hardened"

A new track shoe, which has the quality of becoming "work-hardened" under the continued pounding of extreme applications, has now been made available for the Caterpillar D8 and D9 tractors. Designed primarily for work in rock and slag, the new grouser shoes are cast from high manganese steel containing 12 to 14 percent manganese. The shoes are initially ground smooth on the rail side to provide a smooth, secure shoe-rail fit, and are available in widths of 22 and 27 in., the standard widths, respectively, for D8 and D9 tractors. *Caterpillar Tractor Company.*

Circle number (96) on reply card.

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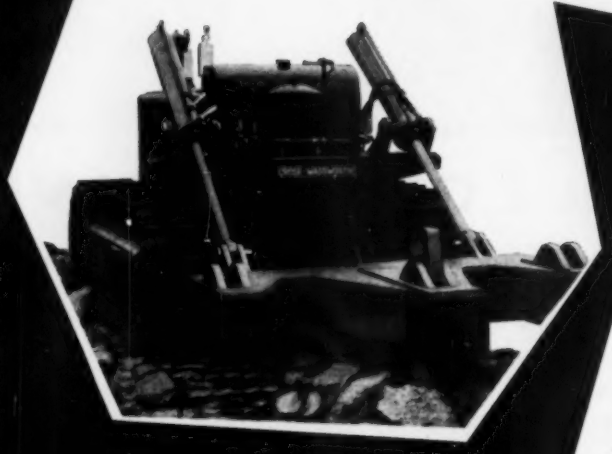

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Barge Loading Arms

Two all-metal models of a river barge and lake tanker loading device, designed for transfer of petroleum products, are available from Chiksan Company. According to the manufacturer, the new device, which is available in both 6 in. and 8 in. diameters, prevents most line handling injuries, minimizes dock clutter and replacement costs, speeds barge loading time, and eliminates hose bursts. Materials handled include black and bright petroleum products and mild caustics. Either unit safely handles products in minus 60 F to plus 225 F temperature range at pressures to 300 psi. *Chiksan Company.*

Circle number (97) on reply card.

Personal Radio Communications

Another step toward the wrist radio concept of personal communications has been accomplished in the new "Handie-Talkie" pocket receiver, and accompanying "Handie-Talkie" pocket transmitter, introduced by Motorola.

The fully transistorized receiver adds a complete new dimension to 2-way mobile radio systems by extending easy communications capability to the man on foot.

The new Motorola pocket receiver picks up all radio signals on a system's frequency, making possible the immediate contact of key personnel. Communications can be maintained with the system's base station or any of its mobile stations.

A second model of the pocket receiver, now being given operational field tests, will provide a selective signaling feature. This means a receiver will pick up only messages meant for the particular individual using the unit. It will ignore all others, even though they are on the same frequency.

Also in the operational field testing stage is the new Motorola pocket transmitter, which together with the pocket receiver, provides full 2-way radio communications to the man on foot. *Motorola, Inc.*

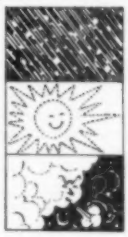
Circle number (98) on reply card.

Transistor-Powered Mobile Radio

New two-way radio equipment contains transistor power for both transmitter and receiver. Units are available either for mounting in the front of a car or truck (as shown) or for placement in

a vehicle's trunk. These transistor-powered designs may be used in low band frequencies (25-54 mc), high band (144-174 mc) and UHF (450-470 mc). *General Electric Communication Products Department.*

Circle number (99) on reply card.



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NEW PIPELINE LITERATURE

Larger Crawler Tractors

A comprehensive discussion of the capabilities of large crawler tractors is given in "Increase Power, Production, Profit", a new 12-page booklet released by Caterpillar.

Printed in two colors, the booklet points up the uses of the D8 and D9 tractors in construction, logging, mining, pipelining, and railroad applications. Brief specifications are given for both machines. Photographs and drawings emphasize the features of torque converters, the oil clutch and the constant "live shaft" power for hydraulic and cable controls, steering clutches and brake boosters. *Caterpillar Tractor Co.*

Circle number (100) on reply card.

Deep Corrugation Sheets

A new publication from Armco Steel describes how Armco Deep Corrugation sheets support greater loads than standard corrugated sheets; also how they cut costs, reduce weight, and save purlins. Comparative safe loads and wider purlin spacing are illustrated, and a safe load vs. purlin spacing chart is scheduled. *Armco Steel Corporation.*

Circle number (101) on reply card.

Rotary Positive Blowers

A new compact design for rotary positive blowers is presented in a bulletin by Roots-Connersville. These blowers, designated Type RAS, feature a vertical arrangement of the impellers to provide horizontal inlet and discharge connections resulting in substantial savings in floor space. A new "segment waist" impeller contour permits larger volumes and higher pressures at no increase in operating speed and with lower power costs. *Roots-Connersville Blower, division of Dresser Industries, Inc.*

Circle number (102) on reply card.

Transistor Servo Amplifiers

A two-page illustrated brochure describes the complete performance specifications and application data of Librascope's Transistor Servo Amplifier, Model 501-2. Particularly suited for controlling small servo motors in high-performance instrument control systems, the transistor servo amplifiers have a voltage gain of 100, with an input impedance of 100K ohms. Also featured in the brochure is information concerning dimensional data and wiring diagrams. *Librascope, Inc.*

Circle number (103) on reply card.

Aluminum Conduit

"Aluminum rigid conduit can now be purchased and installed at a cost comparable to, or less than, that of conventional conduit." This is the opening statement and theme of "Alcoa Aluminum Electrical Rigid Conduit."

Features of aluminum conduit are: Resistance to corrosion; non-magnetic; light weight; good appearance; non-toxic; non-soarking, and freedom from staining. A primary economic advantage outlined is the normally lower cost of installation. Although primarily a descriptive brochure, the booklet gives specific installation instructions and a comprehensive table of dimensions and weights of conduit, couplings, and elbows. *Aluminum Company of America.*

Circle number (104) on reply card.

Lightweight Generators

Highlights of design, engineering, and construction features of the recently introduced Allis-Chalmers G-226 portable, lightweight generator set are covered in a new catalog, BU-412, now available. Included are sketches showing in-use application of the unit, engine cutaways, and photographs of numerous important components that provide long life and economical operation. Specifications of the basic generator set are also included. *Allis-Chalmers Manufacturing Company.*

Circle number (105) on reply card.

Facilities at Mixco

A 6-page folder describing the complete laboratory facilities now available at Mixing Equipment Company is available. The folder outlines the pilot-plant mixing operations of the hazardous materials laboratory and describes the unique uses of the new continuous multistage contactor. General information is given on industrial mixing research and studies at Mixco. *Mixing Equipment Company, Inc.*

Circle number (106) on reply card.

High Sensitivity Controller

Details of a compact pneumatic-electronic control device, said to detect and control changes in media level with exceptional precision are given in Technical Bulletin RF-587 issued by Robertshaw-Fulton. It is said to be particularly valuable for application in vessels or small tanks that do not permit internal installation of conventional systems requiring large detection devices. *Robertshaw-Fulton Controls Company.*

Circle number (107) on reply card.

REILLY

NEW 230 X-1 PRIMER

1. Reilly announces a Plasticized Coal Tar Enamel Primer, designed for maximum bond development.
2. Quick-drying (20 minutes± has been reported).
3. Non-sagging and non-curtaining.
4. Great coverage (750 to 1400 square feet per gal.).
5. Stability of bond — no degradation of bond with time and temperature exposure.
6. Derived wholly from coal tar materials, thus fully conforms to A.W.W.A. and governmental agency standards.
7. Gives 100% reliability factor to coating process when properly applied with plasticized coal tar enamel.

More to come. Reilly 230 X-1 Primer is the first of a series made possible by a significant break-through in applied coal tar surface chemistry. HS X-1 for Reilly Hot Service Enamel and QD X-1 for Reilly Intermediate Enamel will soon be available.

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New Literature

"Closed Circuit" Television

A new 12-page bulletin describes types of industrial television equipment, gives five basic suggestions for equipment selection, and illustrates each with case histories of successful operations.

The case histories are drawn from experience with industrial television in the power industry where temperature extremes and vibration require the ruggedest kind of equipment for satisfactory service. The fundamental problems of application are pertinent to any industry or business considering use of television as an aid to production, as a tool of automation, or as part of plant and personnel safety improvements. *Diamond Power Specialty Corporation, Electronics Division.*

Circle number (108) on reply card.

"Air-Cooled" Heat Exchanger

A cover-to-cover revision of the Fluid Cooler (Air Cooled Heat Exchanger) sales catalog has been completed by The Trane Company. Because of the specialized uses of the air-cooled heat exchanger line, approximately one-third of the catalog is devoted to the types of units normally used in various industrial and process cooling applications. The equipment utilizes ambient out-door air as a cooling medium—no water is required. *The Trane Company.*

Circle number (109) on reply card.

Packaged LACT Systems

Packaged lease automatic custody transfer systems are explained in a bulletin just released. Illustrated and described in detail are two basic systems: (1) Positive meter tank measuring system, and (2) positive displacement meter system. These packaged units are ready for operation and require field hookup only. *Custody Transfer Systems, Division of Murdock Tank & Mfg. Co.*

Circle number (110) on reply card.

Rotameters for Measurement

Bypass Rotameters for measuring fluid rate of flow in pipelines 2 in. in diam and larger are described in Bulletin 18B by Schutte and Koerting Company. The Rotameters are applicable to both liquids and gases. A complete Bypass Rotameter installation is described as comprising an orifice in the main pipeline, and a ½-in. or 1-in. diam by-pass line across the orifice containing a small orifice and an SK Safeguard Rotameter of indicating, alarm, or transmitting type. The two orifices make the by-pass flow directly proportional to the main pipeline flow, and the Rotameter is calibrated to read the main flow directly. The bulletin also contains simplified, easy-to-follow instructions for determining the permanent pressure loss across the main orifice, and the required straight run of pipe before and after the main orifice. *Schutte and Koerting Co.*

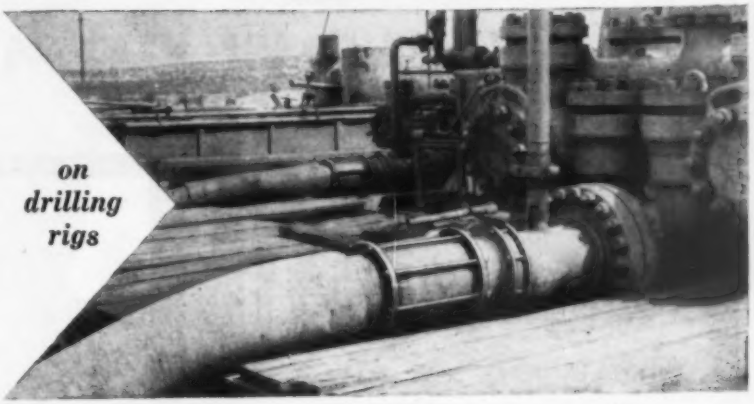
Circle number (111) on reply card.

Nordberg Engines

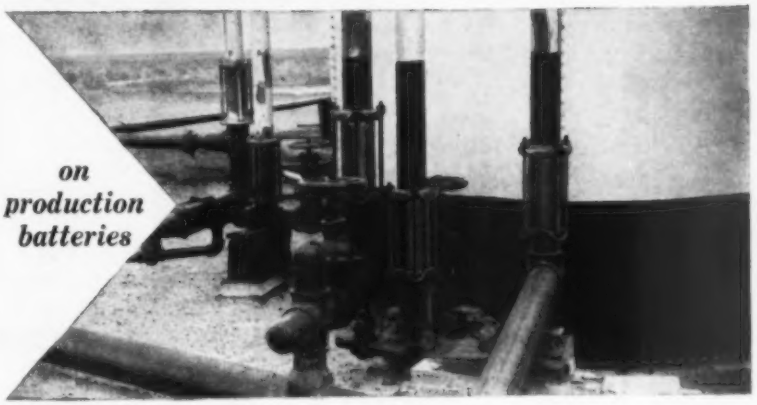
A 16-page bulletin describing Nordberg radial engines, 2-cycle diesel, spark-ignition gas and duafuel, is available. The newly revised 2-color bulletin describes recent engineering and design features, which include supercharging of the spark-ignition radial engines for an increase in rating of approximately 50 percent over normally scavenged engines. A schematic drawing helps to describe the relatively minor and simple modifications required to change from a normally scavenged to a supercharged engine. *Nordberg Mfg. Company.*

Circle number (112) on reply card.

Dresser® Couplings—



fast, vibration proof...



safe, permanent joints!

Dresser Couplings are easily installed . . . only two man-minutes per bolt with a simple hand wrench. The specially compounded Dresser Gasket provides the essential "give and take" to absorb vibration, settlement, and other stresses that might cause damage. It also allows up to 4° pipe deflection at every joint and still maintains a permanent, bottle-tight seal. Eases of take-down and re-usability of Dresser Couplings are a tremendous asset where you may need to add new pumps, valves or lines. Send for Dresser Catalog No. 531. It contains more detailed information and complete specifications on *all* Dresser Couplings, Fittings and Pipe Repair Products.

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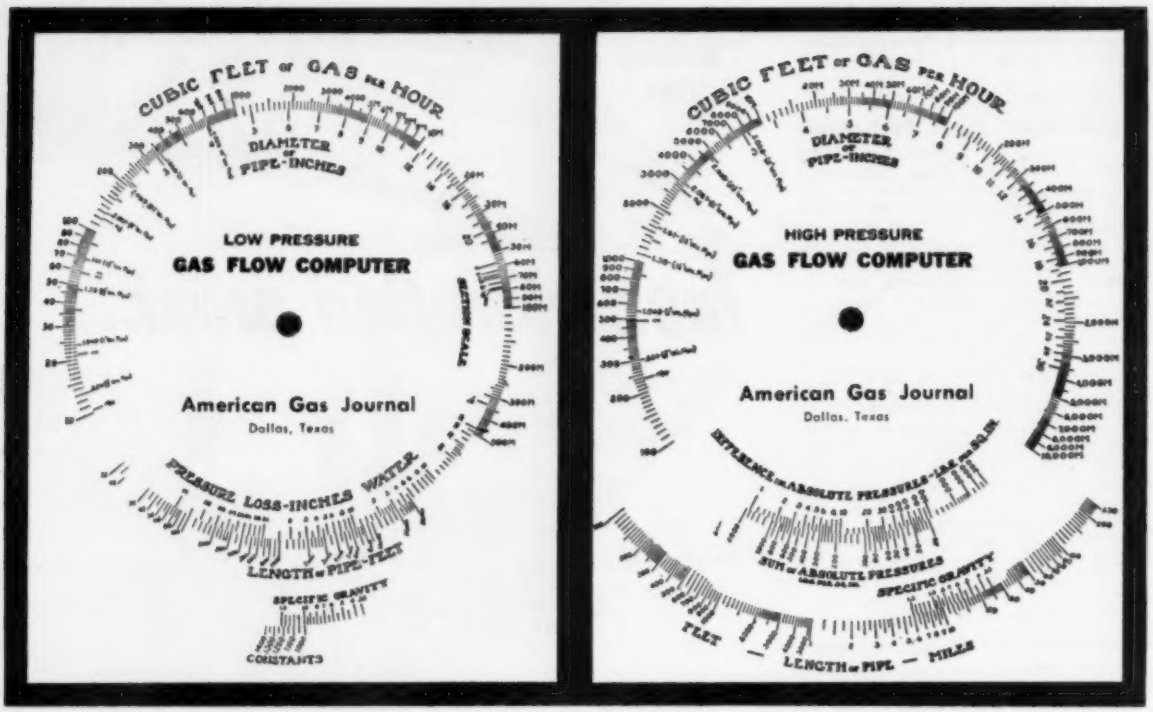
For LOW Pressures

Cubic feet of gas per hour	*10 to 500M*
Pipe diameters	*¾-in. to 48-in.*
Pressure loss (inches)	*.01 to 50*
Specific gravities	*.35 to 1.5*
Constants	*1000 to 1400*
Pipe length (feet)	*30 to 30,000*

For HIGH Pressures

Cubic feet of gas per hour	*100 to 10,000M*
Pipe diameters	*¾-in. to 30-in.*
Difference in absolute pressure to	*500 psi.*
Sum of absolute pressures	*20 to 2,000 psi.*
Specific gravities	*.35 to 1.5*
Pipe length (feet)	*100 to 5,000*
Pipe lengths (miles)	*1 to 250*

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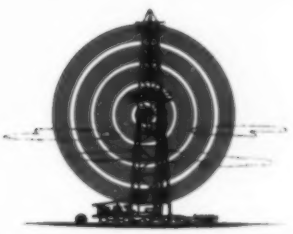
Rig Locator

supplement to

the Petroleum Engineer



OCTOBER 1958

Drilling Rig Locator

An exclusive summary of U.S. and Canadian contract rotary and cable tool rigs . . . plus a SPECIAL SECTION FOR WELL SERVICING EQUIPMENT.

THIRD ANNIVERSARY

The Petroleum Engineer's October 1958

DRILLING RIG LOCATOR

Including U. S. and Canadian Well Servicing Units

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3rd Anniversary Edition

DRILLING RIG LOCATOR

A summary of U. S. and Canadian Drilling Contractors, their names and addresses, location and specifications of both cable tool and rotary rigs; some rigs in foreign service; U. S. offshore rigs; and the NEW WELL SERVICING CONTRACTORS SECTION

Three years and 10 RIG LOCATORS ago . . . *The Petroleum Engineer* pioneered what seemed to be an impossible directory service . . . something never before attempted. It was the first concise listing of contract rigs by states and counties (by province and areas in Canada) ever tabulated. This edition is a milestone . . . and still improvements in its utility go on. In July of this year . . . the first directory of well servicing contractors was added . . . and it has grown considerably in just three short months. As it becomes a useful tool to both the servicing contractor and the producer . . . it, too, will be further expanded.

Well Servicing Rig Directory

This was . . . proportedly . . . another impractical task. Well servicing contracting . . . perhaps not as glamourous . . . nor involving the amount of capital outlay and income as normally associated with rotary drilling. There are more well servicing contractors . . . spread over just as large an area . . . with the average servicing contractor operating on a much smaller basis than the average drilling contractor. Some operate out of their "hip pockets" . . . but . . . the sincere cooperation given by the rotary contractor was enough to give enthusiasm for equal cooperation from the well servicing contractor. And . . . that belief certainly was justified. We are indebted, indeed, not only to those drilling contractors who have long given us their support . . . but especially to the well servicing group who knew little of this new idea. We are encouraged by their help . . . and are already looking to new horizons for bettering this service . . . perhaps to a world wide contractors directory. It's primary purpose is to be of help to you . . . in obtaining new business for you. Your ideas and suggestions are always welcome.

Use of abbreviations. In a directory of this type where certain specifications are included, it was necessary in the conservation of space to make some abbreviations. Under the column of "type power," the following abbreviations apply: Dsl for diesel; gaso for gasoline; stm for steam; btne for butane; and dsl elec for diesel electric. In listing drawworks make and model number, it was necessary to abbreviate the manufacturer's name. Some of these abbreviations are well known; others had to be made to fit the available space. Here's the code we used:

Manufacturer's Company Name	Abbreviation
ALCO Products, Inc. (formerly Beaumont Iron Works Div. of American Locomotive Co.)	ALCO-BIW
Allis-Chalmers Manufacturing Co.	Allis Chmrs
American Iron & Machine Works	Amer
Ansaldo	Ansaldo
Bethlehem Supply Co.	Beth
Big Four Machine & Supply Co.	Big Four
Border Foundry & Machine	Border
The Brewster Co., Inc.	Brwstr
Bucyrus-Erie Co.	B. Erie
Cardwell Manufacturing Co., Inc.	Crdwll
Clark Bros. Co., Inc.	Clark
Fred E. Cooper, Inc.	Cooper
Continental-Emsco Co.	Emsco
Cummins Engine Co., Inc.	Cummins
George E. Failing Co.	Failing
Franks Division of Cabot Shops, Inc.	Frnks
General Machine Co.	Gen Mach
Hacker Machine & Supply Co.	Hacker
Hopper Machine Works, Inc.	Hopper
Houston Tool Co.	Hou
Howard-Turner Machine Works	Howard-Turner
Ideco, Inc.	Ideco
Ingersoll-Rand Co.	Ingersoll
Jones, Shelburne & Guffey Co.	JS&G
Joy Manufacturing Co.	Joy
Mayhew Supply Co., Inc.	Mayhew
Mid-Continent Supply Co., Inc.	M-CSCO
Lee C. Moore Corp.	L. C. Moore
Lucey Export Corp.	Lucey
Muskogee Iron Works	MIW
The National Supply Co.	Natl
Oil Well Supply Division (U. S. Steel Corp.)	"Oilwell"
Reich Bros.	Reich
Spencer-Harris Machine & Tool Co.	Spencer
Stardrill-Keystone Co.	Star
Texas Iron Works, Inc.	TIW
Vickers, Inc.	Vickers
Victoria Machine Works	Vic
Wagner-Morehouse, Inc.	Wgnr-Mrhse
Walker-Neer Manufacturing Co., Inc.	Wlkr-Nr
Waldrip Engineering Co.	Wldrp
Well Machinery & Supply Co., Inc.	Ft. Wrth
Wheeling Machine Products Co.	Wheeling
The Wheland Co.	Whlnd
Wichita Tool Supply Co.	Wich
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wlsn

U. S. Drilling Contractors

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

A

A & P Drlg Co Inc Box 568 Duncan Okla
Abb Drlg Co 300 Oil & Gas Bldg Wichita Falls Tex
Acacia Drlg Co Box 881 Tulsa Okla
Ace Drlg Co 1800 Republic Natl Bk Bldg Dallas Tex
E H Adams Drlg Co Box 1601 Midland Tex
Akin & Dimock 714 Holliday St Wichita Falls Tex
Alan Drlg Co 807 Oil & Gas Bldg Wichita Falls Tex
Aldridge & Stroud Inc Box 962 Odessa Tex
Allen & Morris 820 Alamo Natl Bldg San Antonio Tex
Allen Drlg Co 4410 Venable Ave Charleston 4 W Va
Anderson Drlg Co 730 Wichita Natl Bk Bldg Wichita Falls Tex
Anderson Drlg Contr Box 167 Olney Ill
Anschutz Oil Co Inc Box 1466 Casper Wyo
An-Son Drlg Co 3814 N Sante Fe Oklahoma City 18 Okla
An-Son Offshore Drlg Co 1401 Carondelet Bldg New Orleans La
Appell Petroleum Corp Box 330 Alice Tex
Arapahoe Drlg Co 1020 Pet Club Bldg Denver Colo
Ari-Kan Drlg Co Box 162 Great Bend Kans
Armstrong & Horn Drlg Co 640 Milam Bldg San Antonio 5 Tex
Arrow Drlg Co 407 Philtower Bldg Tulsa Okla
Ashby Drlg Co Ltd 738 Meadows Bldg Dallas Tex
Austin Drlg Co Box 1240 Seminole Okla
Austin-Dunham Inc Box 1240 Seminole Okla

B

B & B Drlg Co Whitlash Mont
B B M Drlg Co 673 San Jacinto Bldg Houston 2 Tex
B J & M Drlg Co Ltd 160 S Fairfax Ave Los Angeles Calif
B-M Drlg Co Inc Box 5218 Bossier City La
Pernie Bailey 2309 Sage Rd Houston Tex
Baird & Pfeifer Drlg Co 316 Kittredge Bldg Denver Colo
Baker & Taylor Drlg Co 712 First Natl Bk Bldg Amarillo Tex
Dorris Ballew Inc Box 561 Natchez Miss
Barnes Core Drlg Co 1350 Roberts Ln Bakersfield Calif
Barnwell Drlg Co Box 1748 Shreveport La
Barnwell Offshore Inc Beck Bldg Shreveport La
Barrett Petroleum Co 423 Masonic Bldg Shawnee Okla
Bass Drlg Co 905 San Jacinto Bldg Houston 2 Tex
Robert M Bass Drlg Contr Box 471 Kilgore Tex
Bay City Drlg Co Inc Box 1389 Bay City Tex
Bayer-Hunefelt Drlg Co 119 Pet Life Bldg Midland Tex
Beardmore Drlg Co 827 Beacon Bldg Wichita Kans
Dudley C Beene Inc Suite 1117 Town House Shreveport La
Bennett & Roberts Drlg Co Drawer 633 Russell Kans
Bennett & Roberts Drlg Inc Drawer 633 Russell Kans
Bennett Drlg Co 1381 E 26th St Tulsa 14 Okla
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Berry Drlg Co Box 67 Saint Jo Tex
Bickerstaff & Tibbets Drlg Co 406 N Marienfeld Midland Tex
Big Chief Drlg Co Box 8837 Oklahoma City 14 Okla
Big Seven Drlg Co 311 Wright Bldg Evansville Ind
Big West Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Bilbo-Redding Drlg Co Inc Box 21045 Houston Tex
Bill's Drlg Ser 617 Union Natl Bldg Wichita 2 Kans
Black Drlg Co 525 Petroleum Bldg Abilene Tex
Forest Blackstock Inc V & J Tower Bldg Midland Tex
Blount Drlg Co Inc 114 Central Bldg Midland Tex
Bodard Drlg Co 313 Masonic Bldg Shawnee Okla
Bolin Oil Co & D H Bolin 1120 Oil & Gas Bldg Wichita Falls Tex
Tom Bomar Well Ser Box 638 Talpa Tex
Boyd & Durst Drlg Contr Box 329 Alice Tex
Brack Drlg Co Inc Box 575 Fort Collins Colo
E G Bradham First Natl Bk Bldg El Dorado Ark
Brannon & Murray Drlg Co Box 672 Coleman Tex
Brantly Drlg Co Inc Box 4935 Midland Tex
D J Branyan Co Box 166 Cushing Okla
Branyan Drlg Co Box 166 Cushing Okla
C E Brehn Drawer 618 Mt Vernon Ill
Brewster-Bartle Drlg Co Inc 1919 Bk of Southwest Houston Tex
Brinkerhoff Drlg Co Ltd 1001 Mobil Oil Bldg Calgary Alberta Can
Zach Brooks Drlg Co Box 31 El Dorado Ark
Brown & Martin Drlg Co Box 731 Gainesville Tex
Curt Brown Drlg Co 516 Mayo Bldg Tulsa Okla
Brown Drlg Co Box 7217 Long Beach 7 Calif
Harry T Bryant Drlg Co Ltd Box 13364 Houston 19 Tex
Bryant-Hayward Drlg Co Box 4627 Oklahoma City Okla
Al Buchanan Drlg Co 2114 Alamo Natl Bldg San Antonio Tex
A O Bullock Drlg Co Box 821 Casper Wyo
Burger Drlg Co Box 327 Coleman Tex
Buzzini Drlg Co Petroleum Center San Antonio 5 Tex
B G Byars Power Drlg Co 319 Citizens Bk Bldg Tyler Tex

C

C H & C Drlg Co Box 4278 Oklahoma City 9 Okla
C N P Drlg Co 404 Staley Bldg Wichita Falls Tex
Cactus Drlg Corp of Tex Box 348 San Angelo Tex
Cactus Drlg Corp Ltd Box 853 Calgary Alberta Canada
Calco Drlg Co 1113 Continental Bk Bldg Ft Worth Tex
Calvert Drlg Inc Box 552 Olney Ill
Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Camay Drlg Co Rocky Mt Div Suite 1130 Denver Club Bldg Denver Colo
Camden Drlg Co Box 1418 Corpus Christi Tex
Camdrill International Inc c/o Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Canadian River Drlg Co 424 Petroleum Bldg Amarillo Tex
Canter Drlg Co 824½ Main St Mt Vernon Ill
J. G. Cantrell Drlg Co Box 1016 Ada Okla
Capitt Drlg Co 814-16 Union Center Wichita Kans
Frank Caraway Drlg Co Box 982 San Angelo Tex
Cardinal Drlg Co 420 Fourth St Bismarck N D
Carmack Drlg Co 1008 Mile High Center Denver Colo
Carpenter-Trant Drlg Co 321 C A Johnson Bldg Denver 2 Colo
Carper Drlg Co Inc Box 905 Hobbs N M
Carroll Drlg Co Inc Box 337 Farmington N M
Carter Drlg Co 1640 W 34th St N Wichita Kans
Casner & Bentz Box 666 Oildale Calif
Chambless-Rosen Drlg Co Box 4294 Oklahoma City 9 Okla
Ford Chapman Hubbs-Roberson Bldg Pecos Tex
Choya Drlg Co Inc 500 W Illinois Midland Tex
Circle Drlg Co Inc 620 Pioneer Bldg Lake Charles La
Dan L Clark Drlg Co 819 Wilson Tower Corpus Christi Tex
Don Clawson 125 W 19th St Ada Okla
Claypool Drlg Co Box 98 St Elmo Ill
Clegg & Hunt 715 Houston Club Bldg Houston Tex
Clinch Drlg Co Box 27 Hazelhurst Miss
Coastal Marine Drlg & Constr Co 450 Bk of the Southwest Bldg Houston 2 Tex
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Comet Drlg Co Box 1143 OCS Lafayette La
Conrey Drlg Co 328 E Broadway Centralia Ill
Conroe Drlg Co Drawer 1741 Corpus Christi Tex
Continental Drlg Co 414 Shell Bldg New Orleans La
Continental Marine Expl Co Box 3050 Houston Tex
Continental Shelf Drlg Corp 916 Richards Bldg New Orleans 12 La
Cook Drlg Co 2305 Continental Life Bldg Ft Worth Tex
Cooper Drlg Co 902 Staley Bldg Wichita Falls Tex
R A Cooper Drlg Co Inc 711 Hulman Bldg Evansville 8 Ind
Coral Drlg Co 6100 Camp Bowie Blvd Ft Worth Tex
Coroco Drlg Co 2807 Mercantile Bk Bldg Dallas Tex
Crawford Drlg Co Box 622 Shreveport La
Cree Drlg Co Inc Box 593 Pampa Tex
Cron & Gracey Corp 1100 Houston Club Bldg Houston Tex
Jess P Cross Drlg Contr 1216 Texas Graham Tex

Milton Crow Inc 420 Commercial Natl Bk Bldg Shreveport La
Crown Rigs Inc 2107 Bk of Southwest Bldg Houston Tex
Harry L Cullet Purefoy Hotel Talladega Ala
Cummins Drlg Co Altamont Ill

D

D & M Drlg Co Inc Box 247 Great Bend Kans
D-K Drlg Co Box 866 Cortez Colo
Clark Dale Drlg Co Inc 308 N Colorado Ave Midland Tex
Danforth Drlg Co 418 Kennedy Bldg Tulsa Okla
R W Darden Drlg Co Box 576 Olney Tex
Davidson Drlg Co Inc 1004 Continental Life Bldg Ft Worth Tex
Edgar Davis Drlg Co 717 Citizens Bk Bldg Abilene Tex
Harvey Davis & Robt H Thompson Co 1731 28th St Bakersfield Calif
Davon Drlg Co Box 1586 Oklahoma City Okla
Davis & Bates Inc 1601 Milam Bldg San Antonio Tex
Dearing Inc Box 655 Dallas Tex
M J Delaney Co 910 Dallas Fed Savings Bldg Dallas 1 Tex
Delaware Drlg Co Box 387 Pawhuska Okla
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Delta Marine Drlg 407 California Co Bldg New Orleans La
Delta Overseas Drlg Co Box 2012 Tyler Tex
Denver Drlg Corp Box 669 Odessa Tex
W L Dillier Box 341 Casey Ill
Dixie Drlg Co Inc 1712 Commerce Bldg Houston 2 Tex
Dixilyn Drlg Corp Box 3427 Odessa Tex
Dixon Drlg Co Box 2320 Abilene Tex
Doak Drlg Co Box 1108 Bristow Okla
Doc Drlg Corp Blackie Drlg Co Inc Neva-Andre Drlg Corp 210 Willow St Franklin La
Donnell Drlg Co 605 Texas Bk Bldg Dallas 2 Tex
Douglas Drlg Co Box 748 Oildale Calif
Drillers Inc 2005 Adolphus Tower Dallas Tex
Drlg & Expl Co Inc Box 35366 Dallas Tex
Drlg & Expl Co of Delaware Inc Box 35366 Dallas 35 Tex
Drilling & Production Co 2907 L St Bakersfield Calif
Dudley & Heath Drlg Co Box 428 Stillwater Okla
N V Duncan Drlg Co 303 Oil and Gas Bldg Oklahoma City Okla
Dunnam & Wyant Drlg Co 816 N Jordan Liberal Kans
Durham Drlg Co Inc Box 204 Midland Tex

E

E & H Drlg Co Box 1058 Graham Tex
Eakle & Holder Drlg Co 116 Mulberry St Evansville Ind
T T Eason Co Div of Eason Oil Co Box 9755 Okla City 2 Okla
Eastland Drlg Co 806 Continental Life Bldg Ft Worth Tex
Eatmon Drlg Co Box 535 Kimball Neb
B F Edington Drlg Co 447 N Market Shreveport La
Edwards & Bissett Inc 1912 N Esperson Bldg Houston Tex
King Edwards (Edwards Drlg Co) Box 1140 Graham Tex
A W Eggleston Inc Box 425 Crowley La
Errol Elkins Drlg Co 460 Rio Grande St Eagle Pass Tex
Ellis 1536 Austin St Colorao City Tex
Ellis Drlg Corp Box 393 Colorado City Tex
Empire Drlg Co 1403 Texaco Bldg Dallas 1 Tex
Empire Drlg Co 650 Fourth Natl Bk Bldg Wichita Kans
Empire States Drlg Corp 1020 Simms Bldg Albuquerque N M
Enterprise Oil Co 7440 La Hore Rd Bakersfield Calif
Ewing Drlg Co Box 807 Breckenridge Tex
Exeter Drlg Co Republic Natl Bk Bldg Dallas 1 Tex
Exploration Drlg Co 607 Natl Bk of Tulsa Bldg Tulsa Okla

F

Fairman Drlg Co Hammersley Fork Pa
Falco Drlg Co Inc Box 1255 Alice Tex
Falcon Seaboard Drlg Co Pan American Bldg Tulsa Okla
Field Drlg Co 1901 Milam Bldg San Antonio Tex
Fitzpatrick Drlg Co 803 Wilson Tower Corpus Christi Tex
Fitzpatrick Drlg Co Inc Box 639 Casper Wyo
Fleeger Drlg Inc 271 Meadows Bldg Dallas 6 Tex
Flournoy Drlg Co Box 1578 Alice Tex
Flournoy-Haston Drlg Co Inc Dowling Bldg Ardmore Okla
Folk Drlg Co 614 Main Yukon Okla
Foree Drlg Co 607 First Natl Bk Bldg Dallas Tex
Fortune Drlg Corp Petroleum Bldg San Angelo Tex
C J Foster Drlg Co Inc Box 657 Richmond Tex
Foster Drlg Co Inc Box 751 Cushing Okla
4-J Drlg and Well Serv Co Box 471 Drumright Okla
Armstrong Fowler Inc 929 Oleander Bakersfield Calif
Frankfort Oil Co Drlg Div Box 747 Dallas Tex
Frank Frawley Drlg Co 823 S Detroit Tulsa 3 Okla
Lloyd R French Co 506 V & J Tower Midland Tex
Frio Drlg Inc 506 Driscoll Bldg Corpus Christi Tex
Frontier Drlg & Prod Co 2003 Wilco Bldg Midland Tex
Fryer & Hanson Drlg Co 2520 Republic Natl Bk Bldg Dallas Tex

G

Gabbert-Jones Drlg Co 514 Orpheum Bldg Wichita Kans
Tine Gaiser Drlg Co Box 1506 Bakersfield Calif
C S Garber & Sons Inc Boyertown Pa
Gardner Bros Drlg Co Inc 1718 Davis Bldg Dallas Tex
Buster Gardner Drlg Co Inc Box 281 New Iberia La
Garr-Woolley Oil Co 901 Cravens Bldg Oklahoma City Okla
Garvey Drlg Co Route 2 Great Bend Kans
Gary Core Drlg Co 215 N Chester Bakersfield Calif
General Drlg Co Colcord Bldg Oklahoma City Okla
General Geophysical Co 750 Houston Club Bldg Houston 2 Tex
General Well Drlg Inc Box 1315 Alice Tex
Gibson Drlg Co Box 1540 Kilgore Tex
Clyde Gibson Drlg Co 712 City Natl Bk Bldg Wichita Falls Tex
Glenn Gillespie & Sons Box 907 Cushing Okla
Gilmour Drlg Co Box 1082 Alice Tex
C G Glasscock Drlg Co 1601 Wilson Tower Corpus Christi Tex
Glendale Drlg Co 906 Hales Bldg Oklahoma City Okla
Glenn Drlg Co 38 Kennedy Bldg Tulsa Okla
Al Godfrey Drlg Co 2875 Cherry Ave Long Beach Calif
Goff-Leeper Drlg Co Box 1749 Ardmore Okla
Gold-Mar Drlg Co Box 732 Dewar Okla
Goldsmith Drlg Co Box 750 Duncan Okla
Goll Graves & Mechling Inc 205 Bearinger Bldg Saginaw Mich
Gordon Drlg Co Box 15 Mt Pleasant Mich
Gore Drlg Co Box 515 Albany Tex
T V Gorman Drlg Contr 621 Staley Bldg Wichita Falls Tex
H O Grace Drlg Co 632 Wichita Natl Bk Bldg Wichita Falls Tex
Jack Grace Drlg Contr 1009 City Natl Bk Bldg Wichita Falls Tex
Luke Grace Drlg Co 1020 Oil & Gas Bldg Wichita Falls Tex
Gracey-Hellums Corp 410 S Coast Bldg Houston 2 Tex
Graham & Klassen Drlg Co Inc 4715 Crenshaw Blvd Los Angeles Calif
Burdette Graham 804 Driscoll Bldg Corpus Christi Tex
Graham Drlg Co 2nd Floor First St Bk Bldg Temple Okla
Graham-Michaelis Oil Co 211 N Broadway Wichita 7 Kans
John Grappe Drlg Co Box 1186 Levelland Tex
Graves Drlg Co Box 583 Ardmore Okla
Gray Drlg Co 220 Wichita Natl Bk Bldg Wichita Falls Tex
Great Western Drlg Co Box 1659 Midland Tex
Green & Dreblow Drlg Co Box 1057 Bakersfield Calif
Greenwood Petroleum Management Inc Eureka Kans
Grey Wolf Drlg Co 1506 Bk of the Southwest Houston 2 Tex
Guadalupe Drlg Co 2505 Princeton Ave Midland Tex
Roy Guffey Drlg Co 5543 Yale Blvd Dallas 6 Tex
Gulf Coast Drlg & Expl Inc Box 2367 Choctaw Sta Laurel Miss
Gulf Drlg Inc Box 598 Lake Charles La
Henry Gwaltney Drlg Co Box 289 Washington Ind

H

H & S Drlg Co 407 Tri State Ins Bldg Tulsa Okla
Hack Drlg Co Box 5108 Abilene Tex
John S Hagestad Drlg Co 3224 Gulf St Bakersfield Calif
Halbert Drlg Co 507 Citizens Bk Bldg Tyler Tex
Clyde Hall Drlg Co Inc Box 4068 Bakersfield Calif
O E Hall Drlg Co 2008 Continental Natl Bk Bldg Ft Worth Tex
Hamman Oil & Ref Co Box 13028 Houston 19 Tex
Haney & Williams Drlg Co 3500 Cherry Ave Long Beach 7 Calif
Hap Drlg Co 2510 First Natl Bldg Oklahoma City Okla
F E Hargraves & Sons Drlg Co Box 573 Oil City La
Harkins & Co Box 1490 Alice Tex
Harper-Turner Drlg Co 904 Hightower Bldg Oklahoma City Okla
John W Harris Drlg Co 525 Wichita Natl Bk Bldg Wichita Falls Tex
Harvey Drlg Co Box 418 Wichita Falls Tex
Harvey Well Serv Inc Box 94 Harvey La
John Haseman Inc 419 Wilson Bldg Corpus Christi Tex
J W Hastings Drlg Co 722 Wichita Natl Bk Bldg Wichita Falls Tex

H F Hatcher & Son Drlg Co Box 164 Smackover Ark
Hawkins-Wilkins Prod Co 373 San Jacinto Bldg Houston Tex
Win Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
Hayes & Sprague Inc 612 S Flower Los Angeles Calif
Hayward Drlg Co Box 295 Enid Okla
John Heard & Co Inc 624 S Cheyenne Tulsa Okla
Helmerich & Payne Inc First Natl Bldg Tulsa Okla
Henderson Drlg Corp 2208 N Esperson Bldg Houston 2 Tex
The Herb Expl Co 342 Lexington Ave Abilene Tex
Herndon Drlg Co Drawer 489 Tulsa Okla
Maxwell Herring Drlg Corp 519 Citizens Bk Bldg Tyler Tex
B M Hester Box 2588 Wichita Falls Tex
Hewgley Drlg Co 704 Wilco Bldg Midland Tex
Hewit-Gulick Drlg Co 2555 1st Natl Bk Bldg Denver 2 Colo
Highland Drlg Co Box 671 Odessa Tex
Hilburn Industries Inc Ricou-Brewster Bldg Shreveport La
J E Hillier Box 67 Pleasanton Tex
C F Hills Drlg Co Box 2158 Pampa Tex
W B Hinton 2900 Mercantile Bk Bldg Dallas 1 Tex
Chas E Hipp Co Box 26 Graham Tex
Hissom Drlg Co 1327 Wilco Bldg Midland Tex
Holliman Drlg Co 712 Fidelity Union Life Bldg Dallas Tex
Holm Drlg Co Box 7246 Tulsa Okla
Holmes Drlg Co 1045 San Jacinto Bldg Houston Tex
W C Holt Drlg Co 920 Enterprise Bldg Tulsa Okla
Slats Honeymon Drlg Co 1310 Liberty Bk Bldg Oklahoma City Okla
R L Horn & Son Drlg Co Pawnee Okla
Hose-Austin Drlg Corp Box 1067 Casper Wyo
Houchins Drlg Co Box 388 Mt Carmel Ill
Houston Oil Well Serv Co 504 Waugh Dr Houston 19 Tex
Howell & Howell 1610 Life of America Bldg Dallas Tex
H H Howell 604 Milam Bldg San Antonio Tex
Hull Oil Co 214 Panhandle Bldg Wichita Falls Tex
Hunter Bros 509 First Natl Bldg Wichita Falls Tex
T F Hunter Estate 509 First Natl Bldg Wichita Falls Tex
Hupp & Hume Box 616 Owensboro Ky
Floyd R Hyer 314 Commerce Bldg Okmulgee Okla

I

Inca Drlg Co 709 Houston Club Bldg Houston Tex
Donald T Ingling 623 First Natl Bk Bldg Wichita 2 Kans
Irish Drlg Co Inc Box 225 Eastland Tex
Iron Drlg Co 1206 Philtower Bldg Tulsa 3 Okla
Isern Drlg Co Box 45 Ellinwood Kans
Ivy Drlg Co 1705 Burton Way Bakersfield Calif

J

J & C Drlg Co Box 552 Refugio Tex
J E B Drlg Co 750 W 5th St Ft Worth Tex
J M C Drlg Interests 6282 E Marshall Tulsa Okla
S W Jack Drlg Co Allegheny Ave Avonmore Pa
Tom Jack Drlg Co Box 288 Sulphur Okla
Jackson Oil Co Box 147 Longview Tex
Charles M Jameson Box 532 Vernal Utah
Jet Drlg Co Inc 304 California Bldg Denver 2 Colo
Jett Drlg Co Inc Box 1832 Shreveport La
Johns Drlg Co 711 Fair Bldg Ft Worth Tex
Al Johnson Drlg Co Rt 12 Box 440 Oklahoma City 10 Okla
Johnson-Bates Drlg Co Box 425 Konawa Okla
Johnson Drlg & Serv Co Box 3 Magnolia Ark
Johnson-Gadbois Drlg Co 200 Petroleum Bldg Abilene Tex
Fred Johnson Drlg Co 2790 Cherry Ave Long Beach Calif
Don Johnston Drlg Co 825 Petroleum Club Bldg Denver Colo
A V Jones & Sons Box 787 Albany Tex
J E Jones Drlg Co Box 1516 Midland Tex
Jones Shelburne & Pellow Oil Co 508 NE 26th St Okla City Okla
Justiss-Mears Oil Co Inc Box 396 Jena La

K

K & E Drlg Inc 719 Union Center Bldg Wichita 2 Kans
K & H Drlg Co Box 1139 Graham Tex
Karper & Glass Box 149 Graham Tex
Kaybert Drlg Co Box 175 Konawa Okla
Keating Drlg Co 510 Natl Bk of Tulsa Bldg Tulsa Okla
K L Kellogg & Sons Box 510 Compton Calif
Kelly Drlg Co Inc Box 1126 Houma La
Kendall-Davis Drlg Co Inc 201 S E 1st St Evansville Ind
Kent & Preston 425 Sayles Blvd Abilene Tex
Keoughan Drlg Co Box 9368 Ft Worth 7 Tex
Kern Drlg Co Inc Box 936 Magnolia Ark
Kerr-McGee Oil Industries Inc Kerr-McGee Bldg Oklahoma City Okla
Kersey & Co Box 305 Artesia N Mex
Kilroy Drlg Co 2306 Bk of Southwest Bldg Houston Tex
Carl B King Drlg Co of Tex Box 270 Midland Tex
King-Phillips Inc 1109 Continental Natl Bk Bldg Ft Worth Tex
Kirby Oil Ind 5107 Center St Omaha 6 Neb
Hugh Kirkpatrick Inc Box 312 Mission Tex
Kirkpatrick Oil Co 1300 N Broadway Okla City Okla
Kirkwood & Morgan Inc 1420 Alamo Natl Bldg San Antonio Tex
A F Knappenberger Box 1139 Graham Tex
Knight Drlg Co Box 1332 Bakersfield Calif

L

L & F Drlg Co Box 1468 Bakersfield Calif
Ralph G Ladd Box 5 Haskell Okla
LaMac Drlg Co Inc 104 S Main St Taylorville Ill
La Mance Drlg Co Box 4457 Midland Tex
Larco Drlg Co Box 3499 Jackson Miss
Latexo Drlg Co Inc 2212 Adolphus Tower Bldg Dallas Tex
Laughlin-Porter Drlg Co Inc Petroleum Life Bldg Midland Tex
J W Lawrence Box 942 Conrad Mont
Layton and Newell Drlg Co Oil & Gas Bldg Ft Worth Tex
Leatherwood Drlg Co Box 925 Jacksboro Tex
LeCuno Oil Corp Box 804 Jefferson Tex
Lee Drlg Co 1007 Philtower Bldg Tulsa Okla
D B Lesh Drlg Co Box 905 Mattoon Ill
Lewis Bros Inc 320 Mile High Center Denver 2 Colo
Ted Lindsay Drlg Contr Box 190 Mt Vernon Ill
M M Lindsey Drlg Co 4748 Airline Hwy Baton Rouge La
H J Lininger Box 37 Upper Sandusky Ohio
Lin-Mour Drlg Co Oil & Gas Bldg Wichita Falls Tex
Llano Drlg Co 301 V & J Tower Bldg Midland Tex
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Lohmann-Johnson Oil Co Inc 320 Indiana Bk Bldg Evansville Ind
Charles E Long Jr Inc Box 961 Midland Tex
Long Engineering Corp 4823 Allum Rd Houston 25 Tex
Louisiana Delta Offshore Corp 201 Carondelet Bldg New Orleans La
Love-Miller Drlg Co Inc 712 Patterson Bldg Denver 2 Colo
Low Drlg Co Box 1112 Cisco Tex
Lowe Drlg Co Box 832 Midland Tex
Lunsford Drlg Co 505 Louisiana Bk Bldg Shreveport La
Lynn Drlg Co 1403 Natl Bk Tulsa Bldg Tulsa Okla
H B Lynn Drlg Corp Box 1085 Farmington N Mex

M

MIM Drlg Corp 1401 Majestic Bldg San Antonio Tex
Mac Drlg Co Box 2972 Houston Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Mallard Drlg Co 1016 Union Natl Bk Bldg Wichita Kans
Mallonee Drlg Co Inc 820 Union Center Wichita Kans
R L Manning Co 318 Continental Oil Bldg Denver Colo
Marcum Drlg Co Box 761 Ada Okla
Marine Drlg Inc 212 Balter Bldg New Orleans La
Maritzky & Bibby Box 509 Homer La
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
Mast Drlg Inc Box 33 Russell Kans
Maxwell Drlg Co Box 846 Coleman Tex
M Mazzarino 104 W Broadway Centralia Ill
McAlester Fuel Co Box 210 Magnolia Ark
McCalman Drlg Co Inc Box 602 Homer La
McClure Oil Co Box 147 Alma Mich
Gene McCutchin Drilling Co Box 1585 Dallas Tex
McDaniel & Beecherl Drlg Co 908 Dallas Fed Savings Bldg Dallas 1 Tex
McDaniel Drlg Co 205 C A Johnson Bldg Denver 2 Colo
A D McDuffie Box 807 Wichita Falls Tex
Lottie B McFann Drlg Co 3901 Cedar Ave Long Beach 7 Calif
W H McGarr Industries Box 472 Eagle Pass Tex
J R McGill 509 Amarillo Bldg Amarillo Tex
B M McGraw Drlg Contr 4412 N Western Oklahoma City Okla
McQueen & Stout Drlg Co 1113 Ft Worth Natl Bk Bldg Ft Worth 2 Tex
Alfred Meier Drlg Co Rt 4 Box 327 Broken Arrow Okla
Melco Drlg Co Box 1360 Seminole Okla
Mercury Drlg Corp 1205 Beck Bldg Shreveport La

Meredith & Co 1418 Bk of the Southwest Bldg Houston Tex
Meredith Drlg Co 419 City Natl Bldg Wichita Falls Tex
Ward S Merrick Box 971 Ardmore Okla
Mesker Drlg Co 1129 E 15th St Tulsa Okla
Midland Drlg Co 410 W Ohio Midland Tex
Midwestern Drillers Inc 1206 Mid-Continent Bldg Tulsa 3 Okla
J Conley Miles Drlg Co Box 1791 Abilene Tex
Milestone Drlg Co Box 314 Midland Tex
Milhoan Drlg Co Box 948 Tulsa Okla
Miller & York Box 936 Bakersfield Calif
Miller Bros & Bowling Box 611 Alice Tex
Gene Miller Inc Box 238 Lawrenceville Ill
J E Miller Drlg Contr Box 1581 Abilene Tex
Joe W Miller 2001 12 St Brownwood Tex
Miracle & Wooster Drlg Co Box 233 Vernal Utah
Miracle-Fifer Drlg Co 1225 First Natl Bk Bldg Denver 2 Colo
Mobile Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Monroe Drilling Co Inc Box 490 Monroe, Louisiana
Montgomery Drlg Co Box 747 El Dorado Ark
J S Montgomery 103 NW 44th St Oklahoma City Okla
Mora Drlg Co 1908 First Natl Bldg Tulsa Okla
Moran Bros Inc 1200 Oil and Gas Bldg Wichita Falls Tex
E F Moran Inc 1805 Natl Bk of Tulsa Bldg Tulsa 3 Okla
E W Moran Drlg Co 500 First Natl Bk Bldg Wichita Falls Tex
Moran Oil Prod & Drlg Corp Box 1718 Hobbs New Mex
Dave Morgan Drlg Co Box 820 Blackwell Okla
Pete Morris Drlg Co Box 733 Ada Okla
Dale Mount Drlg Inc 1155 Mercantile Dallas Bldg Dallas 1 Tex
Mountain States Drlg Co Inc 622 Patterson Bldg Denver Colo
Murfin Drlg Co 617 Union Center Wichita 2 Kans
Musgrove Petroleum Corp 801 Union Center Wichita Kans
Muskegon Development Co 432 Lyman Bldg Muskegon Mich

N

Neal Drlg Co Box 3186 Victoria Tex
Needham Drlg Co Box 1285 Artesia N Mex
Nemaha Oil Co Mercantile Bk Bldg Dallas Tex
Newton Drlg Co Box 1104 Coalinga Calif
Nichols Drlg Co Box 1032 Duncan Okla
Nicklos Drlg Co 518 City Natl Bk Bldg Houston Tex
The Noah Petroleum Co Box 192 Albion Ill
Norman Drlg Corp 1141 Butternut St Abilene Tex
Norton Drlg Co 542 Natl Bk of Commerce Bldg New Orleans 12 La
The Novak Drlg Co Box 2147 Tulsa Okla
Nuckolls-Bell Drlg Co 1255 First Natl Bldg Oklahoma City 2, Okla
Nye & Snell Drlg Co 208 Patterson Bldg Denver Colo

O

Ocean Drlg & Expl Co 2475 Canal St Caribe Bldg New Orleans 12 La
Offshore-Submarex Inc Box 1135 Santa Barbara Calif
Olen Oil Corp Box 2235 Cut Bank Mont
Olds Oil & Chem Corp Box 90 Mt Carmel Ill
R Olsen Liberty Bk Bldg Oklahoma City Okla
W B Omohundro Box 774 Wichita Falls Tex
Oney Drlg Co Box 425 Graham Tex
Orm Drlg Co 421 M & P Bk Bldg Sherman Tex
Ormand Bros Drlg Co Box 1469 Odessa Tex
Ormand Drlg Co Inc Box 1469 Odessa Tex
O' Rourke-McGirl Drlg Co 632 Natl Bk of Tulsa Bldg Tulsa Okla
Overby Drlg Co Inc Box 248 Nowata Okla
Owen Drlg Co Box 1423 OCS Lafayette La
Haynes B Ownby Drlg Co 610 Gulf States Bldg Dallas Tex

P

Paco Petroleum Corp Box 347 Mt Carmel Ill
Paine Drlg Co 301 Insur-O-Medic Bldg Dallas Tex
Pan-Tex Drlg Co 316 Henderson Blvd Kilgore Tex
Parker Drlg Co 418 Natl Bk of Tulsa Bldg Tulsa Okla
Howard Parker Co 1103 Bk of Southwest Bldg Houston Tex
Patton Drlg Co Inc Orpheum Bldg Wichita Kans
Payne Bros Drlg Co 611½ 12th St Box 15 Lawrenceville Ill
Peak Drlg Co Inc 1019 Central Bldg Wichita Kans
Willard Pease Drlg Co Box 1532 Grand Junction Colo
Pegg Bros Drlg Co 1204 Natl Bk of Commerce Bldg San Antonio Tex
Penrod Drlg Co 1320 Mercantile Securities Bldg Dallas Tex
Perforaciones Delta C A Apartado 9138 Caracas Venezuela
Perkins Bros Drlg Co Box 1232 Duncan Okla
Perkins-Houston Drlg Co 618 Wichita Natl Bldg Wichita Falls Tex
Perrine & Perrine Drlg Contr Box 87 Salem Ill
H F Pettigrew Drlg Acct 836 Republic Natl Bk Bldg Dallas Tex
Pickrell Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Pico Drlg Co Box 512 Breckenridge Tex
Pierce Drlg Co 605 Oil & Gas Bldg Wichita Falls Tex
Louis Pitcock Drlg Co Box 25 Graham Tex
C C Pollard Box 65 Ft Stockton Tex
Fred Pool Drlg Co 3106 Lockheed Midland Tex
Pool & Gerlich Drlg Co Box 1940 San Angelo Tex
Poteet Wysor & Eckles Inc Box 508 Holdenville Okla
Powell Drlg Co 412 Union Center Bldg Wichita Kans
Graham Powell Drlg Co 129 N Sycamore St Centralia Ill
The Power Rig Drlg Co Box 1436 OCS Lafayette La
Prime Drlg Co 814-16 Union Center Wichita Kans
Prince Marine Drlg & Expl Co 434 Bk of Southwest Bldg Houston Tex
Producers Drlg Co Inc 927 Natl Bk of Commerce Bldg New Orleans La
T M Pruett Drlg Contr Box 303 Centralia Ill
Pyburn Drlg Co Box 4276 Shreveport La

Q

Quaker Drlg Co Inc 1100 Bitting Bldg Wichita 2 Kans

R

R-G Drlg Co 403 City Natl Bk Bldg Wichita Falls Tex
R W I T Drlg Co 506 Diamond St Holdenville Okla
Ramey Well Serv Suite 401-P Robertson Bldg Wichita Falls Tex
G H Ray Well Serv Box 68 Cement Okla
Reading & Bates Offshore Drlg Co 1502 Philtower Bldg Tulsa 3 Okla
Rebstock & Reeves Drlg Co 450 Saratoga Bldg New Orleans La
Red River Drlg Co Cook Bldg Breckenridge Tex
Reed Drlg Co Inc 1209 Atlas Bldg Tulsa Okla
Reserve Drlg Co Inc Drawer 1612 Casper Wyo
Reserve Drlg Co Inc 625 Union Center Bldg Wichita 2 Kans
Rex & Morris Drlg Co Box 334 El Dorado Kans
Rheay & Reynolds Drlg Co 404 Petroleum Bldg Abilene Tex
Rhodes & Hicks Drlg Corp Box 667 Alice Tex
Rhodes Drlg Co Box 239 Abilene Tex
The R W Rine Drlg Co 420 Union Center Wichita Kans
C M Roberson Drlg Co 418 Market St Shreveport La
Robinson Bros Drlg Co Box 430 Borger Tex
Robinson Drlg Co Box 970 Colorado City Tex
Robinson-Wehmeyer Drilling Co 470 Jacinto Bldg Houston Tex
Rocky Mountain Drlg Co 550 S Flower St Los Angeles Calif
Roden & McRae Drlg Corp Box 2286 Casper Wyo
R Benton Ross Inc 403-P Robertson Bldg Wichita Falls Tex
Rowan Drlg Co Inc Drawer 12247 Ft Worth 16 Tex
J W Rudy Box 684 Clay City Ill
Ruhl Drlg Co Inc 1621 Bk of Southwest Bldg Houston 2 Tex
Rupp-Ferguson Oil Co 522 Union Center Bldg Wichita Kans
A D Rushing Inc 523 W 6th St Los Angeles 14 Calif
Russell & O'Donnell Inc Crawford Hotel Midland Tex
Russell & Russell Drlg & Prod 621 Lindsay St Gainesville Tex

S

Sabre Drlg Co 222 Hughes Bldg Cushing Okla
Sage Drlg Co Inc 1100 Bitting Bldg Wichita 2 Kans
St John Drlg Co Box 639 Ballinger Tex
Salt Dome Prod Co 737 Texas Natl Bk Bldg Houston 2 Tex
San Juan Drlg Co Box 728 Farmington N M
Santa Fe Drlg Co Box 310 Whittier Calif
Santa Rosa Drlg Co Box 633 Apple Valley Calif
Saunders Drlg Inc Box 5383 Sonora Tex
Schafer Drlg Co 2400 Liberty Bk Bldg Oklahoma City Okla
Schulz & Brannan Drlg Co 621 Staley Bldg Wichita Falls Tex
Scooter's Drlg Serv 1215 Stlar Bldg Shreveport La
A B See Drlg Co Inc 206 Petroleum Bldg Abilene Tex
Seibold Drlg Co 106½ N Harrison Cushing Okla
Seran & Howard Drlg Co Box 110 Okemah Okla
SeRoBee Drlg Co Inc 521-22 Union Natl Bk Bldg Wichita Kans

Severns Drlg Co Ltd 639 S Spring St Suite 119 Los Angeles Calif
Harold Shappell Drlg Co 316 City Natl Bldg Wichita Falls Tex
Sharp Drlg Co Box 1271 Midland Tex
Sheets & Walton Drlg Co Box 152 Breckenridge Tex
Sherin Drlg Co Inc 1709 First Natl Bldg Oklahoma City Okla
Shields Drlg Co Inc Shields Bldg Russell Kans
Shields Oil Producers Shields Bldg Russell Kans
Shoreline Drlg Co Inc 1203 Beck Bldg Shreveport La
Shulman Bros Box 191 Vandalia Ill
Signal Drlg & Expl Inc 203 Mayo Bldg Tulsa Okla
Signal Oilfield Serv 203 Mayo Bldg Tulsa Okla
Sills Drlg Co 1350 Roberts Ln Bakersfield Calif
Joe Simpkins 6421 Easton Ave St Louis 14 Mo
Skinner & McDougal Drlg Co Box 8774 Oklahoma City Okla
Don Slape Drlg Co Box 432 Olney Ill
Smallwood & Son 3657 E Kiest Blvd Dallas Tex
Smiley & Little Drlg Co 1635 SE 29th St Oklahoma City Okla
Smith & Breyer Suite 154 Meadows Bldg Dallas 6 Tex
B B Smith Inc Box 5103 Midland Tex
K Smith Cable Tools 1801 Van Buren Great Bend Kans
Ray Smith Drlg Co Simons Bldg Dallas Tex
L C Smitherman Drlg Co Box 627 Augusta Kans
Sojourner Drlg Corp Box 679 Abilene Tex
Sooner Drlg Co 412 Federal Natl Bk Bldg Shawnee Okla
Southeastern Asia Drlg Co 901 Employers Ins Bldg Dallas Tex
Southeastern Drlg Corp 901 Employers Ins Bldg Dallas Tex
South State Drlg Corp Box 448 Mt Vernon Ind
South States Drlg Co Box 147 Longview Tex
J D Sprecher Box 299 Casper Wyo
Star Drlg Co Box 326 Wilson Okla
Stephens Oil & Gas Corp. 1502 Main St Annex Lubbock Tex
Stice Drlg Co Box 678 Beeville Tex
Stickle Drlg Co 920 First Natl Bk Bldg Tulsa Okla
Harold L Strader Drlg Co 3901 Mt Vernon Houston 6 Tex
Strait Drlg Inc Box 90 Eldorado Kans
Strata Drlg Box 355 Great Bend, Kans
C W Strotman Drlg Co 620 S 30th St Mattoon Ill
Stroube Drlg Co Box 730 Corsicana Tex
Sun-Marine Drlg Corp (Off-Shore Constr Inc) Suite 623 2975 Wilshire Blvd Los Angeles 5 Calif
Summit Drlg Corp 414 Atlas Life Bldg Tulsa 3 Okla
The Sun Drlg Co 2975 Wilshire Blvd Los Angeles 5, Calif
Sunnyland Contracting Co Inc Box 388 Rayne La
Sutton Drlg Co Box 6446 San Antonio Tex

T

Target Drlg Corp 421 Mayo Bldg Tulsa Okla
Taylor Expl Co Inc 2118 Welch Ave Houston Tex
W P Taylor Drlg Co 1429 Bk of the Southwest Houston Tex
Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Texas Drlg Co Box 183 Monahans Tex
Texas R F O Inc 421 Meadows Bldg Dallas 6 Tex
Texdrill Corp McClain-Williams Bldg Conroe Tex
Texita Oil Co 812 Milam Bldg San Antonio 5 Tex
Tex-Mex Drlg 1211 Fidelity Union Life Bldg Dallas Tex
Theiss Drlg Co 740 West 5th Ft Worth Tex
Thomas & Billups Drlg 809 Citizens Bk Bldg Abilene Tex
D Thomason Drlg Co Inc 1703 Beck Bldg Shreveport La
A W Thompson Inc Box 2524 Houston Tex
Thrasher Drlg Co 1602 Beck Bldg Shreveport La
Tibbits Drlg Co 1000 Oil and Gas Bldg Wichita Falls Tex
Timberland Expl Co 1069 San Jacinto Bldg Houston 2 Tex
Tolson Drlg Co 213 Triangle Bldg Pawhuska Okla
Trachta Drlg Co Box 67 Muenster Tex
Transit Corp 1516 Liberty Bk Bldg Oklahoma City Okla
Trant Drlg Co 1201 Peoples Bk Bldg Tyler Tex
Triad Drlg Co 119 Featherston Bldg Wichita Falls Tex
Trio Drlg Co 3013 Nussbaumer Dallas 26 Tex
Triple S Drlg Co Rt 1 Box 393 Broken Arrow Okla
Tri-Service Drlg Co Box 1785 Midland Tex
Troop Drlg Co Box 145 St Elmo Ill
Troup & Suttles Inc 506 Diamond Holdenville Okla
True Drlg Co Drawer 1612 Casper Wyo
Tucker Drlg Co Box 1876 San Angelo Tex
Turnbull & Zoch Drlg Co Box 2248 Corpus Christi Tex
C D Turner Drlg Co 501 Permian Bldg Big Spring Tex
Twinoak Drlg Co 210 S Morton Okmulgee Okla

U

R W Uhl 1401 Washington Blvd Bartlesville Okla
Rip C Underwood 553 First Natl Bk Bldg Amarillo Tex
Unit Drlg Co Box 599 Bristow Okla
United Drlg Co Box 986 Longview Tex
United Drlg Co 8750 Holloway Dr Los Angeles 46 Calif
Urice Drlg Co 615 Ft Worth Club Bldg Ft Worth Tex

V

V S & S Drlg Co 1004 Ridgley Bldg Springfield Ill
V-T Drlg Co 711 Hulman Bldg Evansville Ind
Varner-Neill Drlg Co Box 1999 Abilene Tex
W H Varner Drlg Co Box 1999 Abilene Tex
Veeder Supply & Dev Co Box 201 Cherryvale Kans
Viersen & Cochran Box 280 Okmulgee Okla
Viking Drlg Co 102 W Crockett St San Antonio 5 Tex
John W Voss Drlg Co Inc 1322 Highland Dr McAllen Tex

W

WLB Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
Wade Drlg Co Inc 413 Wright Bldg Tulsa Okla
Wagner & Wyant Drlg Co Inc 414 Petroleum Bldg Amarillo Tex
J H Wagner Drlg Co Box 751 Eldorado Kans
Earl F Wakefield 515 Union Center Bldg Wichita Kans
Walters Drlg Co 510 Orpheum Bldg Wichita Kans
Walters Drlg Co Inc 4114 McMillan Dallas 6 Texas
Rusty Walters Drlg Co Box 304 Bakersfield Calif
Ward Drlg Co 106 Oil & Gas Bldg Wichita Falls Tex
Tommy Ward Drlg Co 524 ½ N Kansas Liberal Kans
Travis Ward Drlg Co Box 711 Athens Tex
Warton Drlg Co Box 2807 Odessa Tex
Carnes W Weaver Drlg Co 326 Gulf Bldg Houston Tex
C B Webster Drlg Co 609 San Jacinto Bldg Houston Tex
Webster Drlg Co 304 Mayo Bldg Tulsa Okla
Dick Wegener Drlg Contr 1820 First Natl Bldg Oklahoma City Okla
Well Drillers Inc 2001 First City Natl Bk Bldg Houston Tex
Wells Drlg Co 5382 Cherry Ave Long Beach Calif
Art West Drlg Co 205 Michael Bldg Odessa Tex
West Central Drlg Co 717 Citizens Bk Bldg Abilene Tex
Western Drlg Co Inc 902 Lubbock Natl Bk Bldg Lubbock Tex
Western Offshore Drlg & Expl Co 3500 Cherry Ave Long Beach Calif
Western Serv Drlg Co Inc Box 1428 Odessa Tex
Chester H. Westfall Drlg Co 1612 First Natl Bldg Tulsa Okla
Carl J Westlund Inc Box 197 Midland Tex
Westlund Drlg Co Box 197 Midland Tex
Wheless Drlg Co Box 368 Shreveport La
Wilbanks & Rutter Drlg Co 2200 Scurry St Big Spring Tex
Wilkinson Drlg Co 1121 Union Natl Bldg Wichita Kans
A W Williams Drlg Co Inc 411 Virginia St Mobile Ala
Williams Drlg Co Inc Box 851 Springhill La
Walter W Willis 813 Broadway Mt Vernon Ill
Wilson Drlg Co Inc Box 933 Jackson Miss
C R Winn Drlg Contr Box 331 Salem Ill
Wolfe Drlg Co Box 559 Tulsa Okla
Woodson Prod Co 412 Exposition Dallas 26 Tex
Woolf & Magee Inc Box 635 Tyler Tex
Wright Clark & Senkel Inc Box 267 Graham Tex

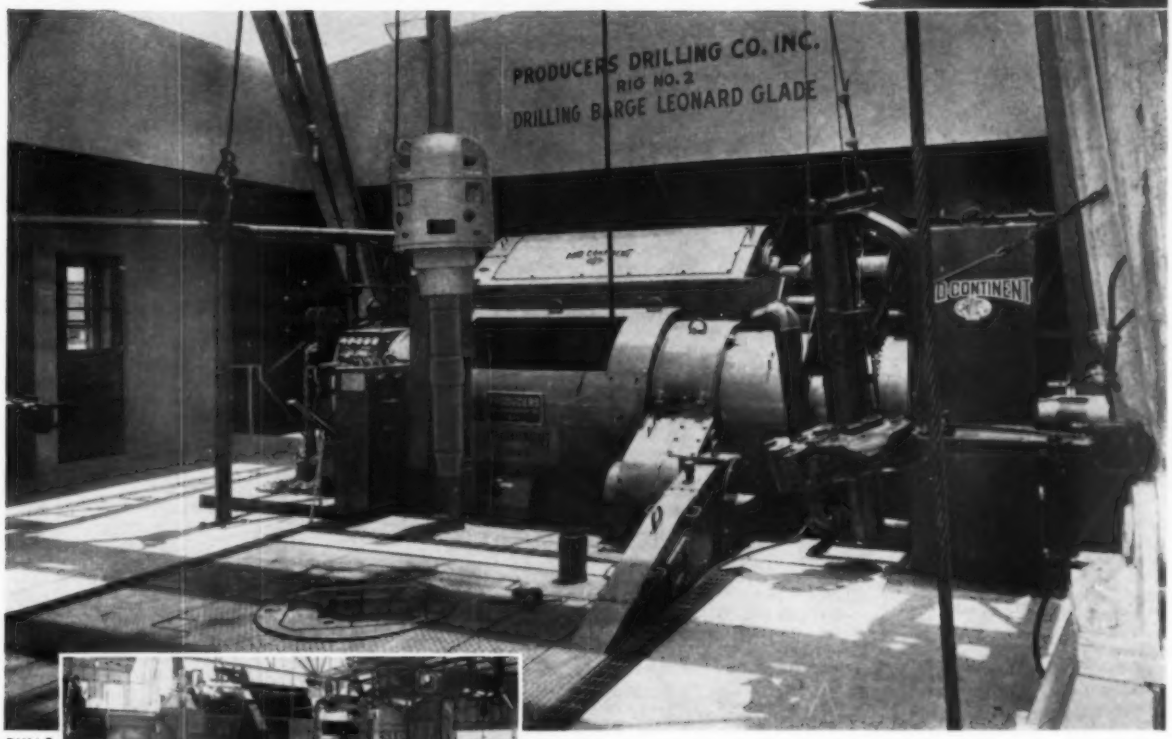
Y

S P Yates Drlg Co 311 Carper Bldg Artesia N Mex
Marshall R Young Drlg Co Box 712 Brookhaven Miss
Wesley C Young Drlg Co Box 5733 Sonora Tex
Zapata Off-Shore Co 2218 First City Natl Bk Bldg Houston Tex

U. S. Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALABAMA						
Mobile County						
Zach Brooks Drlg Co	4	gas	1350	Brwstr N-75	1350	12,000
	7	dsl	1350	Brwstr N-75	1350	12,500
Jett Drlg Co Inc	104	dsl	1250	Brwstr N-75	1000	12,000
	108	dsl	1250	Brwstr N-75	1000	12,000
Sunnyland Contr Co Inc	11	dsl	—	Ideco H-750	520	11,000
ARIZONA						
Apache County						
D-K Drlg Co	1	gas	675	Natl 50	675	7,500
ARKANSAS						
Columbia County						
E G Bradham	1	LPG-gas	—	Crwdll 8	180	6,000
	2	LPG-gas	—	Brwstr N-4	280	7,000
Cook Drlg Co	19	gas-btne	900	Wisn Titan	975	12,500
Kern Drlg Co Inc	3	dsl	260	Emsco GB-250	260	6,000
Franklin County						
Wolfe Drlg Co	3	gas-btne	536	Natl 50	536	7,500
Lafayette County						
Hilburn Industries Inc	2	gas	550	Wisn	—	10,000
Johnson Drlg & Serv Co	1	dsl	200	Beth-Breeze	200	4,500
Kern Drlg Co Inc	2	gas	600	Emsco GB-503	500	7,500
Montgomery Drlg Co	1	gas-btne	700	Emsco GA-600	500	9,500
	2	gas-btne	415	Brwstr N-55	—	7,500
Logan County						
Falcon Seaboard Drlg Co	16	gas-btne	425	M-CSCO U-15	425	8,500
Parker Drlg Co	30	gas	—	Natl 50	700	9,000
Viersen & Cochran	10	gas	325	Natl 50	450	8,800
Miller County						
Milton Crow Inc	4	gas	900	Brwstr N-75	600	10,000
	6	dsl	260	Brwstr N-4	260	5,500
Kern Drlg Co Inc	1	dsl	260	Emsco GA-250	260	5,000
United Drlg Co (Texas)	3	gas-btne	500	M-CSCO U-10	400	7,500
Ouachita County						
H F Hatcher & Son	2	gas-gaso-btne	250	Crdwll S-350	250	5,500
Saline County						
Walters Drlg Co Inc	3	gas	130	Mayhew	130	1,000
	4	gas	130	Mayhew 1000	130	600/2⅛"
	5	gas	150	Mayhew 1000	150	600/2⅛"
	7	gas	175	Mayhew 1000	175	900"2⅛"
Union County						
Cook Drlg Co	22	gas-btne	475	Wisn Mogul	290	7,500
H F Hatcher & Son	1	gaso-gas-btne	225	Crdwll RL-597	165	4,000
Mercury Drlg Corp	1	gas	200	Ideco H-20	200	3,500
CALIFORNIA						
Colusa County						
Brown Drlg Co	3	dsl	825	"Oilwell" 66	550	9,500
Contra Costa County						
Sills Drlg Co	1	dsl	600	Custom	350	5,500/3½"
Fresno County						
Camay Drlg Co	1	gas	1075	Emsco J-1000	1000	12,000
Haney & Williams Drlg Co	3	gas	1250	Natl 75	1350	10,000
Hayes & Sprague, Inc	1	gas	1050	Wisn Titan	1050	13,000
Knight Drlg Co	1	dsl	1020	M-CSCO U-35D	500	8,000
Newton Drlg Co	4-40	dsl	320	Emsco GB-250	—	6,000
Glenn County						
B J & M Drlg Co Ltd	2	gas	450	Emsco GA-500	450	7,500
L & F Drlg Co	3	gas-dsl	1000	Natl 75	—	9,800
Kern County						
B J & M Drlg Co Ltd	4	dsl	600	Natl 50	600	8,500
Barnes Core Drlg Co	D-10	dsl	450	Custom	450	5,500/3½"
	D-11	dsl	225	Custom	225	3,000/3½"
Camay Drlg Co	2	gas	1080	Wisn Titan	1000	12,000
	8	dsl	850	Emsco A-800	1200	12,000
Casner & Bentz	1	gas-btne	445	Emsco GA-250	195	4,500
H Davis & R H Thompson Co	1	dsl	300	Emsco G-300	300	6,000
Douglas Drlg Co	1	btne	125	Emsco	125	2,500
Drlg & Prod Co	1	dsl	325	Crdwll	420	6,000
Enterprise Oil Co	3	dsl	300	Wisn Torcair	150	4,000/3"
	4	dsl-LPG	300	Howard-Turner	200	2,800
Tine Gaiser Drlg Co	A	dsl	600	Natl 50	350	6,500
	B	dsl	800	Emsco GB-500	700	9,500
	C	btne	300	Hopper Hoist	225	3,500
Gary Core Drlg Co	D-7	dsl	450	Custom	225	4,000/3½"
Graham & Klassen Drlg Co Inc	3	gas	1500	Natl 75	1200	11,000
	4	gas	1400	Wisn Titan	1050	10,500
John S Hagestad Drlg Co	1	dsl	570	Emsco GB-350	400	7,000
	3	dsl	625	Emsco GB 350	400	7,000
	4	dsl	680	Ideco H-525	440	7,500
Clyde Hall Drlg Co Inc	5	gas-btne	1000	GB-800	1000	12,000
Ivy Drlg Co	1	dsl	185	Hopper IG	185	1,500
	2	btne	185	Hopper GF	185	3,000
K L Kellogg & Sons	25	dsl	1480	Natl 75	1480	9,500
	28	dsl	1350	Natl 100	1100	13,000
	32	gas	1400	Natl 75	1050	9,500
	36	gas	2475	Natl 125	2475	16,000
L & F Drlg Co	1	gas	300	Emsco GB-250	—	5,000
	2	dsl	500	Emsco GB-250	—	5,000
Miller & York	A	dsl	825	Emsco GC-500	825	10,000
	C	dsl	550	Emsco GB-350	425	6,500
	F	dsl	735	Emsco GA-500	550	8,000
	G	dsl	275	Emsco G-36	275	5,000
	J-11	dsl	210	Hopper GTA	210	3,500
	12	dsl	300	Hopper M	380	6,000
Newton Drlg Co	2	dsl	320	Ideco H-40	—	5,000
Rocky Mountain Drlg Co	10	dsl	1200	Emsco J-1000	1550	15,000
	12	gas	1200	Emsco J-1250	1500	20,000
	14	gas	1200	Emsco J-1250	1500	20,000
Rusty Walters Drlg Co	1	dsl	300	Wisn Mogul	300	7,000/4"
Los Angeles County						
Camay Drlg Co	4	gas	555	Emsco 500	500	7,500
	5	gas	535	Natl 50	500	7,000
	6	gas	605	Natl 50	500	7,000
	7	gas	535	Emsco G-300	300	6,000
Drlg & Prod Co	2	dsl-gas-gaso	325	Crdwll D	432	6,000
Gary Core Drlg Co	D-8	dsl	225	Custom	15	2,500/2⅛"
	D-9	dsl	381	Custom	381	4,500
Haney & Williams Drlg Co	1	dsl	450	Wisn Gnt Trcr	300	5,500
	6	elec	850	Natl 75	500	10,000
Hayes & Sprague Inc	2	dsl	1950	Natl 125	1950	16,000
Fred Johnson Drlg Co	1	gas-gaso	1050	Emsco J-1000	1050	12,000
	2	gas-gaso	1750	Emsco J-1000	1050	10,000
	3	gas-gaso	700	Natl 50	700	6,500
	4	elec	600	Natl 50	600	800
K L Kellogg & Sons	18	gas	925	Natl 50	650	7,000
	19	dsl	1200	Natl 75	790	9,500
	29	gas	1370	Natl 75	700	9,500
Macrate Prod Co	2	dsl	300	Ideco HD-30	190	3,500
	7	gas	300	Wgnr-Mrhse	250	4,000
Lottie B McFann Drlg Co	1	gas-btne	550	Natl 50	450	7,000
Rocky Mountain Drlg Co	7	gas	1200	Natl 100	1110	15,000
Santa Fe Drlg Co	3	gas	900	Emsco G-500	440	7,500
	29	elec	1000	Natl 3410-1/2FE	800	15,000
The Sun Drlg Co	2	gas	1400	Natl 125	1250	15,000
	3	elec	750	Natl 110	1100	15,000
	4	elec	1000	Natl 110	1100	15,000
Wells Drlg Co	2	dsl	325	Mobile Blitz 622	350	5,000
Monterey County						
Newton Drlg Co	1	dsl	300	Ideco H-30	—	4,000
Napa County						
Brown Drlg Co	2	dsl	825	"Oilwell" 66	550	9,500
Orange County						
H Davis & R H Thompson Co	2	dsl	300	Emsco GA-250-T	300	6,000
Santa Fe Drlg Co	26	gas	1200	Wisn Titan	900	10,000
San Benito County						
Green & Dreblow Drlg Co	1	dsl	600	Wisn Giant	600	7,500
San Bernardino County						
Santa Rosa Drlg Co	1	prop-gas	155	—	130	2,000
San Joaquin County						
Brown Drlg Co 7 "Mighty Mole"		dsl	900	Emsco GC-350	600	9,500
	H	dsl	275	Emsco GA-250	275	5,000
Santa Fe Drlg Co	11	gas	600	Wgnr-Mrhse	220	6,000
Rusty Walters Drlg Co	1	dsl	300	Cooper D-50	300	6,500/4"
Santa Barbara County						
Casner & Bentz	2	gas-btne	800	Emsco GA-450	550	8,000
The Sun Drlg Co	1	dsl	950	Natl 110	1425	15,000
Santa Clara County						
Drlg & Expl Co of Del Inc	20	gas-gaso	1200	Natl 100	900	13,500
	31	gas-gaso	1500	Natl 130	1200	18,000
Solano County						
B J & M Drlg Co Ltd	1	dsl	600	M-CSCO 35-D	400	7,000
Tehama County						
Brown Drlg Co	9	gas	900	Natl 50-CA	450	8,500
Ventura County						
B J & M Drlg Co Ltd	3	gas	450	Natl 50	775	8,500
Camay Drlg Co	3	gas	855	Natl 75	650	9,000
	9	gas	1900	Natl 130	1900	16,000
Drlg & Expl Co of Del Inc	28	gas-gaso	800	Natl 50A	750	10,000
	29	gas-gaso	1500	Natl 34-10	1200	18,000

MID-CONTINENT U-914 DRAWWORKS SELECTED FOR "LEONARD GLADE"



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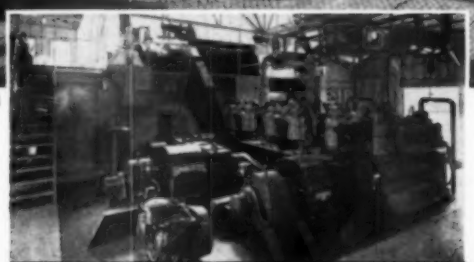


Mid-Continent S-612-A Swinging Compound* on the *Leonard Glade*.

Main slush pumps on the *Leonard Glade* are an Emsco D-1000 and D-700.

Producers Drilling Co., Inc. of New Orleans has selected Mid-Continent's 1400 horsepower U-914 drawworks for their recently-completed drilling barge *Leonard Glade*. This is the second barge-mounted rig completely equipped by Mid-Continent for Producers. The first barge, the *W. F. Youngblood*, was launched in 1957.

Major items of drilling equipment provided by Mid-Continent for the *Leonard Glade* include the drawworks, a Mid-Continent S-27½-A rotary table, a Mid-Continent S-162-A Swinging Compound* rig drive, Emsco D-1000 and D-700 slush pumps, a 14" unitized mud-mixing pump, and a Lee C. Moore cantilever-type mast.

For information about any item of drilling equipment or machinery, contact your Mid-Continent representative.

* PATENTED

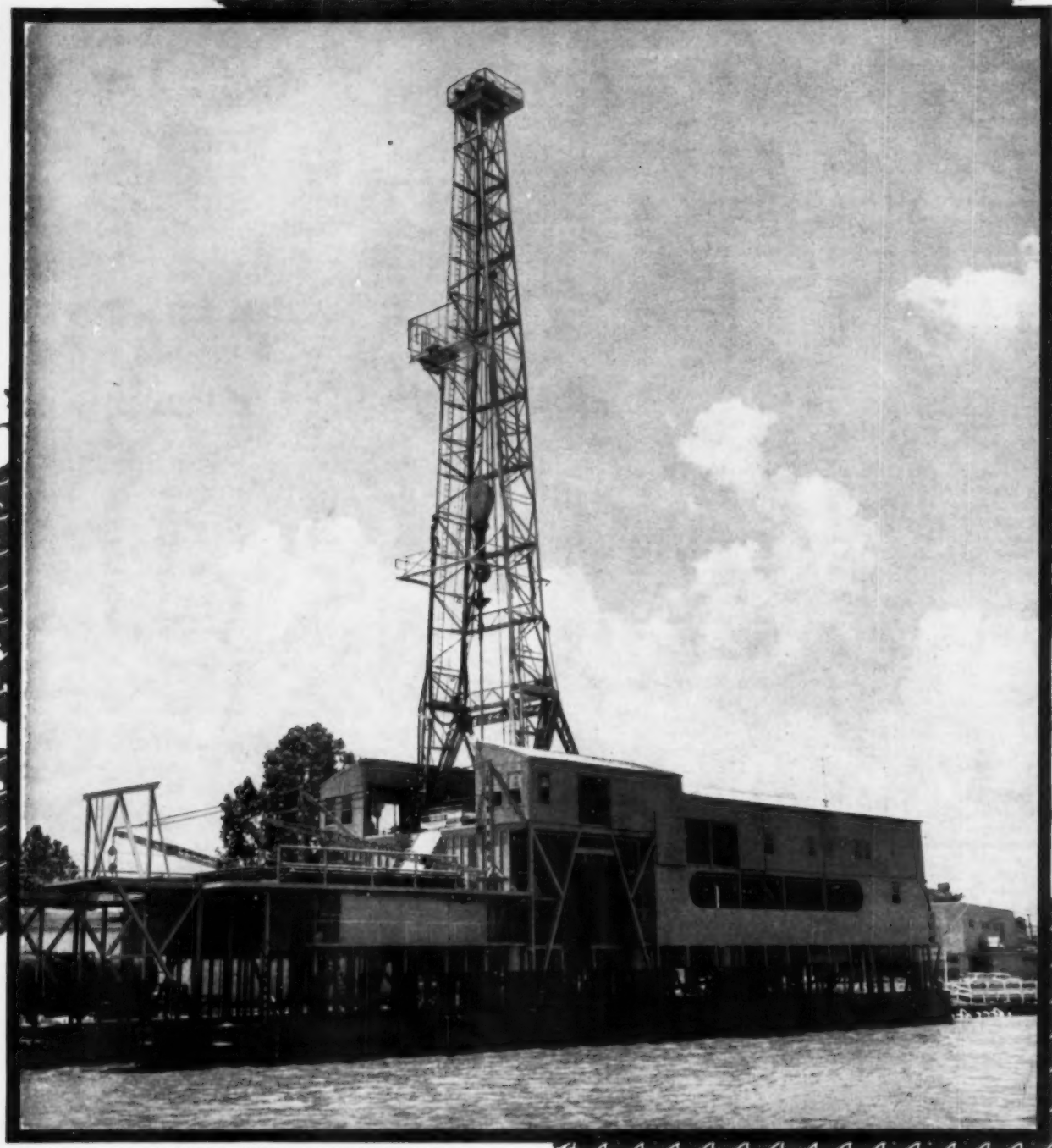
MID-CONTINENT SUPPLY CO.

MID-CONTINENT BUILDING • FORT WORTH, TEXAS
Export Division: 45 Rockefeller Plaza, New York 20, N. Y. Cable: MIDCUMPORT NYK

THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Armstrong Fowler Inc	2	dsl	200	Natl T-12	250	3,000
Graham & Klassen Drlg Co Inc	2	gas	1400	Natl 75	1050	10,500
Green & Dreblow Drlg Co	2	dsl	600	Wisn Giant	600	8,500
Haney & Williams Drlg Co	2	gas	1050	Natl 50	700	8,000
	5	gas	1750	Wisn Titan	1050	13,000
K L Kellogg & Sons	7	gas	2240	Natl 100	1050	13,000
	23	gas	2090	Natl 75	790	9,500
	27	gas	2000	Natl 100	1050	13,000
	31	gas	1580	Natl 125	1050	16,000
	33	gas	1750	Emsco GB-800	1050	12,000
	34	gas	2475	Natl 125	2475	16,000
	35	dsl	1800	Natl 130	1800	18,000
Rocky Mountain Drlg Co	1	gas	1200	Natl 75	900	11,000
	2	gas	1200	Natl 75	900	11,000
	3	gas	1200	Natl 100	900	14,000
	4	gas-dsl	1400	"Oilwell" 96	1750	20,000
	5	gas	1480	"Oilwell" 96	1850	20,000
	6	gas	1200	Emsco J-1000	1550	15,000
	8	gas	1400	Natl 125	1750	20,000
	9	gas	1200	Natl 125	1500	20,000
	12	gas	1480	Natl 125	1850	20,000
	15	gas	1200	Emsco J-750	900	11,000
A D Rushing Inc	1	dsl	—	Natl 40	875	4,800
	2	dsl	—	Ideco 7-11	1610	12,000
	3	gas	—	Natl 50	1075	7,500
	4	gas	—	Wisn Trair Gnt	1700	9,000
	5	gas	—	Natl 50	1075	7,500
Santa Fe Drlg Co	9	gas	1050	Wisn Titan	900	10,000
	25	gas	1200	Natl 55	900	10,000
	28	gas	1200	Natl 80-B	1350	12,000
Severns Drlg Co	1	gas	1350	Natl 100	1350	11,000
The Sun Drlg Co	5	gas	1850	Natl 110	1500	15,000
United Drlg Co	1	gas	450	Emsco EDA	450	6,000
COLORADO						
Baca County						
Holm Drlg Co	5	dsl	300	"Oilwell" 52 T	300	5,500
Bent County						
Holm Drlg Co	4	dsl	560	Wisn Giant	300	5,500
Garfield County						
Carmack Drlg Co	5	gas	400	Natl T-32	320	6,000
Willard Pease Drlg Co	1	dsl	340	Stratmaster 90	320	5,500/3½"
Grand County						
Anschutz Oil Co Inc	8	gas	900	M-CSCO U-15	650	8,500
Jackson County						
Anschutz Oil Co Inc	10	dsl	800	Brwstr N-55	600	8,000
Herndon Drlg Co	8	gas	600	Natl 50-A	750	10,500
Don Johnston Drlg Co	1	dsl	270	Natl T-12	195	5,000
La Plata County						
Anschutz Oil Co Inc	4	gas	800	Wisn Giant	700	8,500
Exploration Drlg Co	10	gas	505	M-CSCO U-15	400	8,000
Gardner Bros Drlg Co Inc	19	gas-btne	185	Crdwll R	200	3,300
Great Western Drlg Co	20	dsl	265	Frnks SAL-1600	600	5,500
Nichols Drlg Co	10	gas-btne	450	Wisn Giant	450	7,500
Urice Drlg Co	1	gas-btne	700	Emsco GA-500	700	8,500
Las Animas County						
Earl F Wakefield	2	dsl	640	Wisn Gnt Rdair	640	8,500
Lincoln County						
Sabre Drlg Co	3	dsl	285	M-CSCO U-36	560	7,500/4"
Logan County						
Exeter Drlg Co	2	btne	320	Emsco GA-250	250	6,600/4"
Jet Drlg Co Inc	1	dsl	300	Emsco G-500	500	6,500
Mesa County						
Nye & Snell Drlg Co	4	dsl	320	M-CSCO U-15	320	6,000
Moffat County						
Camay Drlg Co Rocky Mt Div	1	gas	775	M-CSCO U-15	600	8,500
	5	gas	680	Natl 50-A	450	8,000
Falcon Seaboard Drlg Co	25	dsl	212	Beth S-55	212	6,500
Montezuma County						
Exploration Drlg Co	16	gas	625	Natl 75	600	9,000
Don Johnston Drlg Co	3	gas-btne	750	Natl 50	750	7,500
The Novak Drlg Co	2	gas	300	M-CSCO U-10	—	6,500
Nye & Snell Drlg Co	1	gas	550	"Oilwell" 66	550	6,000
Montrose County						
Mountain States Drlg Co Inc	15	gas-dsl	1400	Natl 125	—	15,000
Morgan County						
Ashby Drlg Co Ltd	1	dsl	300	Natl T-20	300	8,000/3½"
Garvey Drlg Co	17	dsl	300	Wisn Rdair	450	7,000/3½"
	19	dsl	300	Wisn Rdair	450	7,000/3½"
Rio Blanco County						
Carpenter-Trant Drlg Co	1	btne	185	Crdwll RL	185	3,000
Delta Drlg Co	25	gas-btne	1520	Emsco J-1250	1250	15,000
Kerr-McGee Oil Ind Inc	4	gas	900	Natl 75	832	11,500
	42	gas	970	Natl 75	818	11,500
Nye & Snell Drlg Co	2	dsl	320	Wisn M-46	320	5,000
San Miguel County						
Mountain States Drlg Co Inc	11	gas-dsl	1000	Natl 80-B	—	12,500
Washington County						
Garvey Drlg Co	12	dsl	300	Wisn Giant	320	6,000/3½
Love-Miller Drlg Co Inc	1	dsl	500	Wisn Gnt Rdair	824	9,000
Weld County						
Baird & Pfeifer Drlg Co	1	dsl	650	M-CSCO U-15	—	9,500
Exeter Drlg Co	1	dsl	325	Emsco GA-350	425	7,000
FLORIDA						
Madison County						
Dorris Ballew Inc	3	dsl	760	Wisn Titan	1900	15,000
ILLINOIS						
Bond County						
Claypool Drlg Co	2	btne	300	Natl T-12	185	4,500
C R Winn Drlg Contr	1	dsl	135	Wisn Super	135	2,800/3½"
Christian County						
LaMac Drlg Co Inc	1	dsl	—	Wisn Giant	600	4,700
Joe Simpkins	3	dsl	350	Frnks 4000	350	4,000
	4	dsl	350	Spencer	350	2,500
V S & S Drlg Co	2	dsl	—	Wisn	—	2,400
Clark County						
D B Lesh Drlg Co	3	dsl	200	Natl T-20	200	4,000
Clay County						
Claypool Drlg Co	1	btne	300	Natl T-20	185	4,500
Don Slape Drlg Co	4	dsl	300	Brwstr N-4	245	4,500
Clinton County						
Calvert Drlg Inc	12	dsl	260	Ideco H-30	260	4,500
Conrey Drlg Co	1	gas	140	Wisn Super	140	2,000/3½"
Ted Lindsay	1	dsl	220	Crdwll S	160	4,500
M Mazzarino	—	gas-gaso	200	Frnks 2000	200	2,500
Perrine & Perrine Drlg Contr	1	btne	—	Crdwll S	185	6,000
Edwards County						
General Geophysical Co	27	dsl	—	—	400	4,500
Fayette County						
Troop Drlg Co	1	gas-gaso	—	Natl T-20	200	4,500
Franklin County						
C E Brehn	2	dsl	240	Brwstr N-45	—	7,000
Calvert Drlg Inc	16	dsl	260	Ideco H-35	190	5,000
Gallatin County						
Calvert Drlg Inc	11	dsl	260	Natl T-32	190	5,000
V S & S Drlg Co	4	dsl	—	Beth	—	4,200
	5	gas	—	Crdwll	—	4,000
Hamilton County						
C E Brehn	1	dsl	240	Brwstr N-45	—	7,000
Calvert Drlg Inc	8	dsl	260	Ideco H-30	190	4,500
Herndon Drlg Co	9	gas	240	Natl T-25	390	4,000
Shulman Bros	1	dsl	330	Crdwll S-350	—	5,500
Joe Simpkins	3	dsl	500	Natl T-20	500	5,000
Don Slape Drlg Co	5	btne	360	Natl T-12	260	4,500
Walter W Willis	2	dsl	278	Natl T-12	237	4,500
Jasper County						
W L Dillier	1	dsl	—	Natl T-12	212	3,000
Jefferson County						
E F Moran Inc	3	btne	300	Crdwll S	300	4,000
J W Rudy	1	dsl	150	Natl T-20	185	5,000
C R Winn Drlg Contr	2	dsl	225	Crdwll L	225	4,000/3½"
Kenkakee County						
Moran Bros Inc	11	dsl	300	Wisn Gnt	450	6,000
	14	dsl	250	Natl T-12	350	4,500
Lawrence County						
W L Dillier	2	gas	—	Failing 2500	130	2,000
	3	gas	—	Failing 2500	130	2,000
Gene Miller Inc	5	dsl	300	Brwstr N-4	—	4,500
Marion County						
Canter Drlg Co	2	dsl	—	—	180	3,000/3½"
Conrey Drlg Co	2	dsl	175	Wisn Super	175	2,500/3½"
Graham Powell	1	dsl	—	Natl 50	—	6,000
T M Pruett Drlg Contr	1	dsl	300	M-CSCO U-15	300	8,000
Walter W Willis	1	dsl	—	Beth S-45E	—	4,500
Richland County						
J W Rudy	50	dsl	250	Natl 50	214	6,000
Don Slape Drlg Co	1	dsl	260	"Oilwell" 64-A	230	5,000
	2	dsl	240	M-CSCO U-34	230	4,500
	3	dsl	260	"Oilwell" 64-B	230	5,500
St. Clair County						
Henry Gwaltney Drlg Co	3	gas	100	—	100	1,500
Saline County						
Eakle & Holder Drlg Co	1	dsl	300	Brwstr N-4	200	5,500
	2	dsl	400	Emsco G-300	400	5,500
Kendall-Davis Drlg Co Inc	1	dsl	300	Wisn Mogul	300	4,000
Wabash County						
Olds Oil & Chem Corp	1	btne	—	—	200	3,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Paco Petroleum Corp	1	dsl	320	Natl T-32	320	6,000
Washington County						
Ted Lindsay	3	dsl	160	Ideco H-30	160	4,000
Graham Powell	2	dsl	—	Natl T-12	—	3,200
Wayne County						
Herndon Drlg Co	5	gas	375	Brwstr N-4	375	4,500
D B Lesh Drlg Co	1	dsl	200	Natl T-20	200	4,000
	4	gas	450	Natl 50	450	7,000
Ted Lindsay	2	dsl	220	Natl T-16	220	5,000
White County						
Herndon Drlg Co	7	gas	409	Natl T-32	559	4,500
E F Moran Inc	1	btne	300	Brwstr N-4	600	6,000
	2	btne	300	Natl T-12	300	4,500
Paco Petroleum Corp	3	dsl	320	M-CSCO U-35	320	7,000
Joe Simpkins	1	dsl	—	Emsco GA-160-T	500	3,500
INDIANA						
Gibson County						
Houchins Drlg Co	1	gas	185	Natl T-12	185	4,500
The Noah Petroleum Co	1	dsl	300	Brwstr N-4	300	5,500
Paco Petroleum Corp	2	btne	200	Wisn Mogul	165	4,000
South State Drlg Corp	1	dsl	100	Crdwll	110	3,100/2⅛"
Pike County						
Henry Gwaltney Drlg Co	1	dsl	200	Natl T-12	165	3,000
Hupp & Hume	2	dsl	165	Natl 40	300	3,000
Olds Oil & Chem Corp	2	btne	—	—	85	1,500
Posey County						
Anderson Drlg Contr	1	dsl	150	Crdwll 67-L	150	4,000
Kendall-Davis Drlg Co Inc	2	dsl	300	Crdwll S	300	4,000
E F Moran Inc	4	btne	300	Brwstr N-3	300	3,500/3½"
IOWA						
Dallas County						
Kirby Oil Ind	—	gas-gaso	400	Mayhew 3000	145	3,000
	—	dsl	400	Brwstr N-4	400	4,500
	—	dsl	300	M-CSCO U-34	275	4,500
KANSAS						
Barber County						
Beardmore Drlg Co	1	dsl	300	Natl 50	450	6,000
Gabbert-Jones Drlg Co	2	gas	450	Emsco 350	450	7,000
Garvey Drlg Co	3	dsl	175	M-CSCO U-15	296	5,000
	9	dsl	175	Wisn Giant	296	5,000
Patton Drlg Co Inc	1	gas	—	Natl 50	450	7,000
	2	dsl	—	Natl 50	350	6,000
Prime Drlg Co	5	dsl	300	Natl T-20	300	5,000
Barton County						
Ari-Kan Drlg Co	1	dsl	165	Natl T-12	130	4,500
Garvey Drlg Co	14	dsl	175	Wisn Giant	296	5,000
Isern Drlg Co	1	dsl	450	M-CSCO U-15	450	7,000
Quaker Drlg Co Inc	2	dsl	185	M-CSCO U-34	350	4,500
Reserve Drlg Co Inc (Kans)	3	dsl	320	Natl T-32	320	5,500
Chase County						
Rex & Morris Drlg Co	1	dsl	260	Natl T-25	260	4,000
Clark County						
Stickle Drlg Co	6	dsl	300	Brwstr N-45	300	6,500
Comanche County						
Pickrell Drlg Co	10	dsl	270	Ideco	300	6,500
Cowley County						
Peak Drlg Co Inc	14	gas-LPG	200	Brwstr N-35	200	4,000
Edwards County						
L C Smitherman Drlg Co	3	dsl	265	Brwstr N-4	265	5,500
Stickle Drlg Co	4	dsl	300	Ideco H-35	300	5,000
Ellis County						
McMonee Drlg Co Inc	1	btne	220	Beth Breeze	200	4,500
Murfin Drlg Co	2	dsl	200	Natl T-20	260	5,000
Prime Drlg Co	3	dsl	275	M-CSCO U-34	285	4,500
Quaker Drlg Co Inc	1	dsl	185	Wilson Mogul	185	3,600
Shields Drlg Co Inc	3	dsl	300	Wisn Giant	400	6,000
Finney County						
Graham-Michaelis Drlg Co	5	dsl	275	Crdwll B	275	4,000
Helmerich & Payne Inc	26	gas	500	Emsco GB-500	700	9,000
Graham County						
Empire Drlg Co (Kans)	1	dsl	300	Natl T-32	300	5,000
Iron Drlg Co	7	dsl	268	Emsco GB-160	236	4,500
K & E Drlg Inc	2	dsl	285	Natl T-20	—	5,000
Murfin Drlg Co	4	dsl	260	Wisn Rdair	450	7,000
Stickle Drlg Co	5	dsl	300	Natl T-32	300	5,500
Veeder Supply & Dev Co	D	dsl	280	Natl T-25	300	4,500
Grant County						
Garvey Drlg Co	22	dsl	300	Wisn Mogul 42	450	7,000
Greenwood County						
Greenwood Petroleum Mgmt Inc	1	dsl	—	Franks 5000	—	—
Harper County						
Garvey Drlg Co	5	dsl	175	M-CSCO U-15	296	5,000
Herndon Drlg Co	6	gas	409	Natl T-32	559	6,000
Dale Mount Drlg Inc	114	gas	570	Crdwll	570	7,000
Musgrove Petroleum Corp	3	dsl	440	Natl 50	—	5,500
Pickrell Drlg Co	1	dsl	450	M-CSCO U-15	450	6,500
Strata Drlg Inc	1	dsl	520	M-CSCO U-15	520	8,500
Walters Drlg Co	1	gas-btne	—	Natl 50	500	5,500
Harvey County						
Brack Drlg Co Inc (Colo)	5	dsl	—	M-CSCO U-10	380	5,500
Iron Drlg Co	6	dsl	240	Emsco GA-250	268	5,000
Haskell County						
D & M Drlg Co Inc	2	gas-btne	225	Brwstr N-4	280	5,000
R W Rine Drlg Co	5	gas-btne	520	Brwstr N-55	550	8,500
Hodgeman County						
Garvey Drlg Co	8	dsl	175	Wisn Giant	296	5,000
Graham-Michaelis Drlg Co	3	dsl	300	Crdwll S	175	5,000
Kingman County						
Gabbert-Jones Drlg Co	1	gas	380	Emsco 300	380	5,000
	3	gas	380	Emsco 300	380	5,000
Garvey Drlg Co	10	dsl	175	Wisn Giant	296	5,000
Murfin Drlg Co	3	dsl	260	Natl T-20	260	5,000
Transit Corp	3	dsl	280	Emsco	—	4,500
Kiowa County						
Capitt Drlg Inc	3	dsl	525	Beth C-50	500	8,500
	4	gas-btne	300	Beth MC-250	500	5,000
	6	dsl	410	Beth C-50	500	8,500
Rupp-Ferguson Oil Co	1	dsl	350	Ideco H-35	350	5,000
Marion County						
Wilkinson Drlg Inc	1	dsl	300	M-CSCO U-34	335	4,000
McPherson County						
Capitt Drlg Inc	2	dsl	300	Beth S-45	285	5,000
Donald T Ingling	4	dsl	225	Brwstr N-4	225	5,500
Veeder Supply & Dev Co	E	dsl	270	Franks 658	270	3,500
Meade County						
D & M Drlg Co Inc	1	gas-btne	550	Natl 50	550	7,500
	3	dsl	600	M-CSCO U-15	600	7,500
R W Rine Drlg Co	1	gas-btne	620	M-CSCO U-15	600	7,500
Unit Drlg Co	2	gas-btne	900	M-CSCO U-15	900	8,500
Morton County						
Schafer Drlg Co	3	gas-gaso	400	M-CSCO U-15	600	10,000
Norton County						
Bennett & Roberts Drlg Inc	3	dsl	250	Emsco 250	250	5,000
Pratt County						
Powell Drlg Co	1	dsl	—	Emsco GB-350	350	6,500
Rooks County						
Garvey Drlg Co	11	dsl	175	Wisn Giant	296	5,000
Transit Corp	2	dsl	280	Emsco	—	4,500
Earl F Wakefield	1	dsl	440	Wisn Mogul Rdair	440	5,000
Russell County						
Bennett & Roberts Drlg Co	1	dsl	250	Emsco 250	250	5,000
Mast Drlg Inc	2	dsl	185	Natl T-32	250	5,500
Shields Drlg Co Inc	2	dsl	300	Beth C-50	300	8,000
Saline County						
Mallard Drlg Co	1	dsl	285	Emsco G-300	285	4,000
Sedgewick County						
Garvey Drlg Co	15	dsl	175	Wisn Giant	296	5,000
Peak Drlg Co Inc	12	gas-LPG	220	Natl T-12	220	4,000
Seward County						
Bennett & Roberts Drlg Co	2	dsl	250	Emsco 250	250	6,000/3½"
Graham-Michaelis Drlg Co	4	dsl	500	M-CSCO U-15	500	7,000
	8	dsl	400	Crdwll D	400	5,000
Sheridan County						
Herndon Drlg Co	10	gas	409	"Oilwell" 64-A	559	4,500
Stafford County						
Prime Drlg Co	2	dsl	300	Beth S-45	300	5,000
Wilkinson Drlg Inc	2	dsl	300	M-CSCO U-15	335	6,000
Sumner County						
Beardmore Drlg Co	2	dsl	300	Emsco 300	320	4,000
Capitt Drlg Inc	5	gas-btne	250	Beth FC-200	400	4,500
Falcon Seaboard Drlg Co	27	gas-btne	185	M-CSCO U-34	210	5,000
K & E Drlg Inc	1	dsl	285	"Oilwell" T-52	—	6,000
Musgrove Petroleum Corp	8	dsl	230	Natl 50	—	5,000
Trego County						
Transit Corp	4	dsl	280	Emsco	212	4,500
Wilson County						
Smiley & Little Drlg Co	4	gas	100	Wisn	100	2,600
KENTUCKY						
Breathitt County						
Moran Bros Inc	1	gas	1000	Wisn Titan	1200	14,000



142' LEE C. MOORE CANTILEVER MAST.

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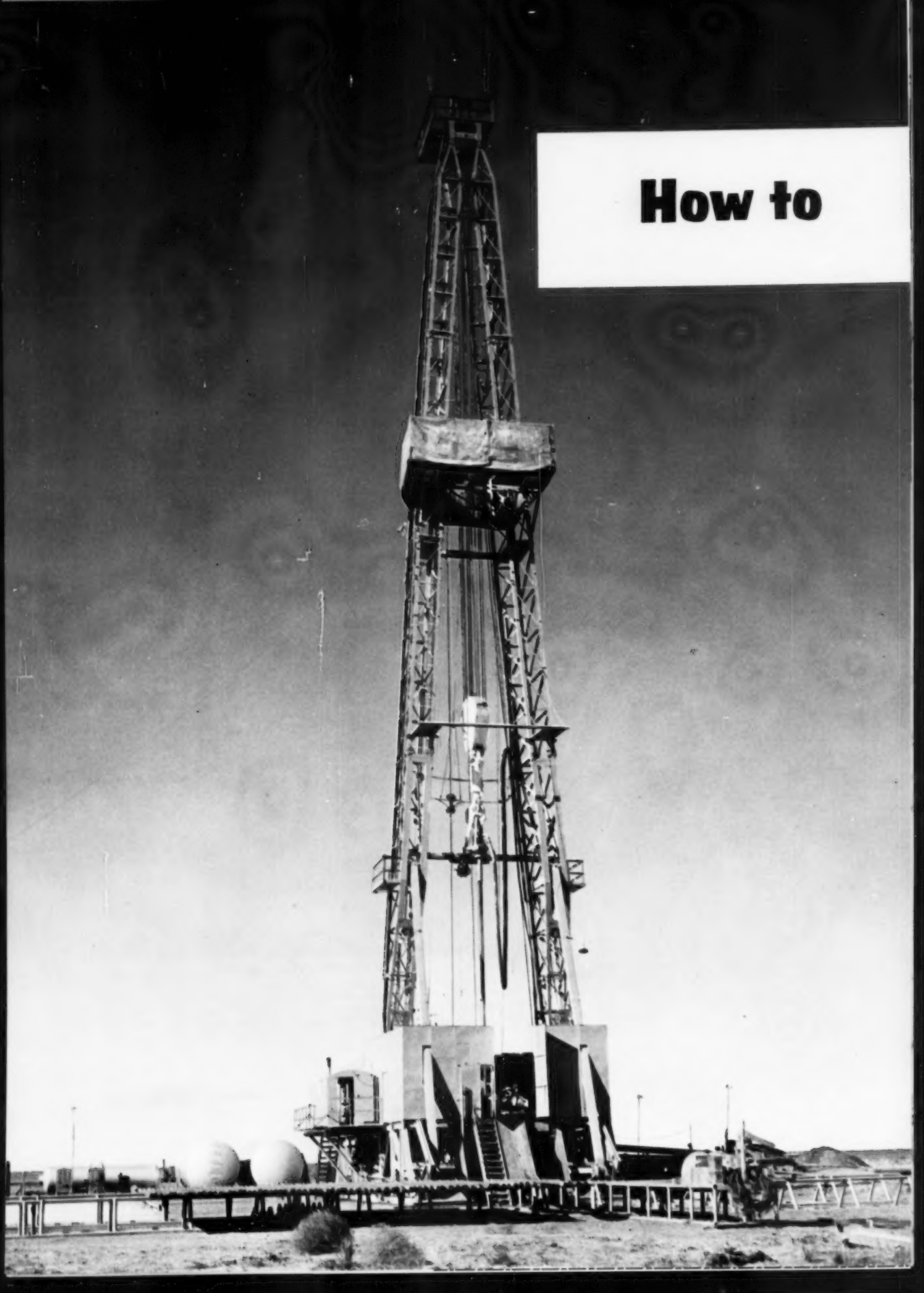
Lee C. Moore

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Daviess County						
Henry Gwaltney Drlg Co	2	gas-prop	200	Crdwll	165	3,000
Henderson County						
Shulman Bros	2	dsl	330	Crdwll L	—	3,500
V-T Drlg Co	1	dsl	220	Crdwll H	160	4,000
Hopkins County						
Eakle & Holder Drlg Co	3	dsl	300	Ideco H-30	300	5,500
Muhlenberg County						
Hupp & Hume	1	dsl	325	Natl 40	350	4,500
Powell County						
Overby Drlg Co Inc	1	dsl-btne	180	Mayhew 1000	—	1,000
	3	btne	250	Mayhew 2000	250	2,000
Webster County						
Big Seven Drlg Co	1	dsl	300	Emsco GB	300	4,500
LOUISIANA						
Acadia Parish						
Pernie Bailey	1	gas	650	Brwstr N-75	—	11,000
Circle Drlg Co Inc	2	gas-btne	800	Brwstr N-75	900	11,000
Delta Drlg Co	14	stm	900	Ideco Big Gnt	1690	15,000
	21	gas-btne	800	Natl 75	650	9,500
Drlg & Expl Co of Del Inc	36	stm	1400	Natl 34-8	—	15,000
C J Foster Drlg Co Inc	1	stm	—	Natl	1000+	18,000
Kilroy Drlg Co	1	gas	1200	"Oilwell" 96	1200	15,000
Nicklos Drlg Co	11	stm	—	Natl	—	17,000
Owen Drlg Co	3	gas	900	Ideco M-1000	—	12,500
	7	stm	1000+	Emsco	—	16,000
	9	stm	740	Ideco Big Gnt	940	16,000
Penrod Drlg Co	33	gas-btne	—	—	1230	12,000
Prince Marine Drlg & Expl Co	3	gas	900	"Oilwell" 66	900	10,500
Rowan Drlg Co Inc	4	gas-btne	900	Natl 75	1149	11,000
Sunnyland Contr Co Inc	3	stm	—	Emsco ECB	720	16,000
Carnes W Weaver Drlg Co	2	gas-btne	900	Ideco	—	11,000
	7	stm	—	M-CSCO U-117B	—	14,000
Allen Parish						
Inca Drlg Co	2	dsl	1000	Beth M-58	1000	10,500
Ascension Parish						
Win Hawkins Drlg Co	2	gas-btne	300	M-CSCO U-15	485	9,000
Assumption Parish						
Delta Drlg Co	11	stm	1000	Emsco UBLS-54	1690	15,000
Dixie Drlg Co Inc	2	dsl	1350	Beth	2000	17,500
Falcon Seaboard Drlg Co	12	stm	1200	Natl 2310-1/2FE	2000+	20,000
Grey Wolf Drlg Co	1	gas-btne	945	Emsco GB-800	—	12,500
Nicklos Drlg Co	15	gas-btne	—	Natl 80	1000	13,000
W P Taylor Drlg Co	1	gas	—	Emsco	1000	13,000
Beauregard Parish						
Owen Drlg Co	6	gas	600	Natl 75	600	12,000
The Power Rig Drlg Co	3	gas-btne	1000	Emsco A-800	—	13,000
Sunnyland Contr Co Inc	8	gas-gaso	—	Crdwll D	312	8,000
Bienville Parish						
Pyburn Drlg Co	2	gas	250	Wilson	800	9,000
Bossier Parish						
Dudley C Beene Inc	2	dsl	285	Brwstr N-3	185	4,000
F E Hargraves & Sons Drlg Co	4	dsl	275	Brwstr N-A	300	6,000/3½"
Penrod Drlg Co	2	gas-btne	—	—	580	7,000
Ruhl Drlg Co Inc	1	—	475	Brwstr N-7	625	8,500
Scooter's Drlg Serv	4	dsl	300	Wlsn Giant	300	4,500
Wheless Drlg Co	1	gas-btne	600	Brwstr N-45	600	7,500
	Bge 10	gas-btne	900	Brwstr N-7	700	9,500
Caddo Parish						
Barnwell Drlg Co Inc	4	gas	500	Wlsn Gnt	185	5,000
Dudley C Beene Inc	1	gas	145	Brwstr N-2	145	2,500
Milton Crow Inc	3	gas	600	Brwstr N-7	400	7,500
B F Edington Drlg Co Inc	102	gas-gaso	120	Failing	180	1,500/2⅛"
	104	gas-gaso	150	Joy	250	2,500/2⅛"
F E Hargraves & Sons Drlg Co	2	btne	185	Brwstr W-50	185	2,800/3½"
	3	btne	185	Brwstr W-50	185	2,800/3½"
Jet Drlg Co Inc	3	dsl	1000	Brwstr N-75	700	11,000
Lunsford Drlg Co	1	LPG	185	Brwstr N-3	145	4,000
	2	LPG	145	Wlsn Spr	145	2,500
C M Roberson Drlg Co	1	gas-btne	400	Brwstr N-45	400	7,300
Tex-Mex Drlg Co	11	stm	—	—	1000+	12,000
Calcasieu Parish						
Pernie Bailey	2	gas	800	M-CSCO U-40	—	11,000
Circle Drlg Co Inc	4	gas-btne	800	Brwstr N-75	960	11,000
Clegg & Hunt	9	btne-gas	—	Natl 50-A	—	9,800
Gulf Drlg Inc	1	gas	375	Frnks SAL-5000	450	5,000
	2	gas	750	Wlsn Spr Titan	1200	12,500
Mac Drlg Co	11	stm	800+	Natl 23-9F-ED	1000+	20,000
Owen Drlg Co	1	stm	540	Ideco Big Gnt	—	15,000
Penrod Drlg Co	16	gas-btne	—	—	1500	15,000
Cameron Parish						
Circle Drlg Co Inc	3	gas-elec	1200	Ideco Big Gnt	2100	15,000
	5	gas-btne	1200	Brwstr N-12	1440	15,000
Clegg & Hunt	8	dsl	—	—	1275	18,000
Delta Drlg Co	20	gas-btne	1520	Emsco J-1250	1250	15,000
Buster Gardner Drlg Co Inc	3	dsl	—	Beth 1013	—	17,500
Win Hawkins Drlg Co	1	stm	—	Alco BIW 14	—	15,000
Mac Drlg Co	10	gas-btne	1000	Natl 130	1300	20,000
Penrod Drlg Co	4	gas-btne	—	—	1425	15,000
	Bge 47	dsl-elec	1250	Emsco EDA	1250	20,000
C B Webster Drlg Co	6	stm	1100	Emsco ECA-10½	1200+	15,000
Wheless Drlg Co	Bge 12	gas-btne	1200	Natl 80	800	12,000
Catahoula Parish						
Jackson Oil Co	2	dsl	250	Spencer	200	6,000/3½"
Justiss-Mears Oil Co Inc	10	dsl	250	Emsco G-250	325	10,000/2⅞"
Scooter's Drlg Serv	2	dsl	300	Brwstr N-4	300	4,500
Claiborne Parish						
Delta Drlg Co	17	gas-btne	1020	Emsco J-1100	1300	15,000
Drlg & Expl Co of Del Inc	32	stm	1400	Emsco ECA	—	15,000
Maritzky & Bibby	1	gas	330	Brwstr	185	5,000
	2	gas	330	Crdwll	145	3,000
Wheless Drlg Co	2	gas-btne	600	Wlsn Atlas	700	8,500
	3	gas-btne	600	Emsco GB-350	600	7,500
	5	stm	900	Emsco UBLS-54	1000+	11,000
Woolf & Magee Inc	5	gas-btne	800	Beth MC-450	800	11,000
Concordia Parish						
Dorris Ballew Inc	6	dsl	380	M-CSCO U-15	600	7,500
Scooter's Drlg Serv	3	dsl	600	Brwstr N-55	600	6,000
De Soto Parish						
McCalman Drlg Co Inc	1	dsl	—	Brwstr N-4	300	5,500
Franklin Parish						
B-M Drlg Co Inc	2	gas	685	Emsco GB-350	500	8,000
Montgomery Drlg Co	3	gas-btne	225	Crdwll S	200	5,000
Iberia Parish						
Clegg & Hunt	3	dsl	—	Wlsn Titan 56	800	11,500
Nicklos Drlg Co	20	pwr	2350	Natl 130	2250	18,000
Prince Marine Drlg & Expl Co	1	dsl	1500	"Oilwell" 96	1500	15,000
Wheless Drlg Co	Bge 6	gas-btne	1000	Wlsn Titan	1000	12,000
Iberville Parish						
Crown Rigs Inc	6	gas	900	Beth MC-450	600	10,000
Jackson Parish						
Cook Drlg Co	18	gas-btne	670	Wlsn Atlas	650	10,000
Jefferson Parish						
Brewster-Bartle Drlg Co Inc	9	dsl	—	"Oilwell" 96	1500	16,000
Cron & Gracey Corp	4	dsl	1450	"Oilwell" 96	1290	15,000
Harvey Well Serv Inc	Bge 1	dsl	600	Frnks SAL-5000	600	7,500/3½"
Rowan Drlg Co Inc	Bge 1	dsl-elec	1600	Emsco ECA	2475	18,000
	Bge 6	dsl-elec	1200	Emsco ED	2800	18,000
	Bge 26	dsl	1325	Natl 100	1545	14,000
Jefferson Davis Parish						
Clegg & Hunt	1	stm	—	Emsco 10	—	15,000
Falcon Seaboard Drlg Co	11	stm	1000+	Alco BIW 12	1200+	17,000
Kilroy Drlg Co	4	gas	1000	Ideco 7-11	1000	12,000
C B Webster Drlg Co	8	stm	1600	Natl FE-34-10	1200+	15,000
Wheless Drlg Co	4	stm	1000+	Emsco UBLS-54	1000+	12,000
Lafayette Parish						
Crawford Drlg Co	1	dsl	695	Brwstr N-7	500	9,000
Owen Drlg Co	4	stm	1000+	Emsco UBLS-54	—	14,000
Penrod Drlg Co	17	dsl	—	—	1464	14,000
	23	dsl	—	—	730	9,000
Rowan Drlg Co Inc	8	gas-btne	1920	Natl 125	1920	18,000
C B Webster Drlg Co	3	gas	900	Emsco J-1250	1300	15,000
Lafourche Parish						
B B M Drlg Co	7	stm	—	Emsco EC-54	—	18,000
Brewster-Bartle Drlg Co Inc	6	dsl	—	"Oilwell" 96	1500	—
Clegg & Hunt	4	stm	—	Ideco Bg Gnt	—	15,000
	Bge 11	dsl-elec	2600	Ideco 2500	1900	23,000
Crawford Drlg Co	2	stm	—	Emsco ECA	500	15,000
Cron & Gracey Corp	3	dsl	—	TIW CT-5	520	8,000
Delta Drlg Co	35	gas-btne	1200	Emsco J-1100	1200	15,000
Doc Drlg Corp	Bge DAN	dsl	1500	Beth 1013	1500	18,000
Blackie Drlg Co Inc	Bge DOC	dsl	1500	Beth Tornado	1500	15,000
Neva-Andre Drlg Corp						
Howell & Howell	3	gas	—	Emsco	696	15,000
	7	stm	—	Emsco	600	15,500
	8	stm	—	Alco BIW DNT	12 500	17,250
Inca Drlg Co	5	gas	1300	Natl 80-B	1300	13,500
M M Lindsey Drlg Co	2	gas	290	Natl T-32	—	6,000
Marine Drlg Inc	1	stm	1800	Emsco ECB	1000+	15,000
	3	stm	1800	Emsco EDA	1000+	15,000
	4	dsl-elec	3000	Emsco EDA	1600	20,000+
	5	stm	1800	Emsco UBL 54	1000+	15,000

How to



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SUPPLY DIVISION – Tulsa

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Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Norton Drlg Co	Bge 6	dsl	1400	Emsco J-1250	1200	17,000
Penrod Drlg Co	Bge 51	dsl	—	Emsco EDES	1200	20,000
Rowan Drlg Co Inc	Bge 14	dsl-elec	1600	Emsco ECA	2325	18,000
Southeastern Drlg Corp	9-Bge 2	dsl	1200	"Oilwell" 96	1600	18,000
	14-Bge 1	dsl	1200	"Oilwell" 96	1600	18,000
Sunnyland Contr Co Inc	9	dsl	—	Crdwll D	450	8,000
C B Webster Drlg Co	Bge 9	dsl	1850	Emsco J-1400	2200	16,000
Wheless Drlg Co	Bge 9	dsl	1300	Natl 130	1300	16,000
	Bge 11	gas-btne	1200	Emsco J-1250	1250	13,500
LaSalle Parish						
Justiss-Mears Oil Co Inc	6	dsl	250	Emsco G-250	325	7,000/4"
Mercury Drlg Corp	2	gas	200	Wisn Mogul	200	4,000
Thrasher Drlg Co Inc	1	gas-btne	350	M-CSCO U-15	600	8,500
Lincoln Parish						
Arrow Drlg Co	16	gas-elec	840	Emsco	—	10,000
Barnwell Drlg Co Inc	9	gas	1800	Brwstr N-95	1800	20,000
Delta Drlg Co	8	stm	750	Ideco Supr-Duty	1200	12,000
Johnson Drlg & Serv Co	2	dsl	500	Beth Twister	300	6,500
McAlester Fuel Co	—	btne-gas	—	Emsco GC-500	820	11,000
Madison Parish						
Marshall R Young Drlg Co	1	—	900	Natl 75	648	11,500
Ouachita Parish						
Cook Drlg Co	10	gas-btne	900	Wisn Titan	975	12,500
	17	gas-btne	670	Wisn Atlas	650	10,000
H & S Drlg Co	2	gas-btne	1000	Brwstr N-95	1000	14,000
Jet Drlg Co Inc	5	gas-btne	700	Emsco 800	800	10,500
Plaquemines Parish						
Brewster-Bartle Drlg Co Inc	5	dsl	—	"Oilwell" 96	1500	16,000
	12	dsl	—	"Oilwell" 96	1500	16,000
Clinch Drlg Co	Bge 1	dsl	—	Emsco GA-350	426	8,500
Cron & Gracey Corp	2	stm	—	Natl 23-9-FEC	—	15,000
Falcon Seaboard Drlg Co	Bge 4	dsl-elec	2700	Beth B-3661	2000	22,500
Buster Gardner Drlg Co Inc	1	dsl	—	Beth M-58	—	9,500
Gracey-Hellums Corp	Bge 1	stm	1000	Natl 34-10FE	1200	15,000
M M Lindsey Drlg Co	1	gas	380	Brwstr N-55	—	7,500
Penrod Drlg Co	Bge 41	dsl	—	—	1000	12,000
	Bge 44	dsl-elec	—	—	1400	18,000
The Power Rig Drlg Co	8	gas-btne	1500	Ideco 7-11	—	15,000
Producers Drlg Co Inc	1	dsl	2000	M-CSCO U-1220	2200	20,000/5"
Rebstock & Reeves Drlg Co	1	dsl	1050	Wisn Sup Titan	1425	15,000
Rowan Drlg Co Inc	Bge 21	dsl-elec	1000	Emsco EC	1920	12,000
Southeastern Drlg Corp	20-Bge 6	dsl	1200	"Oilwell" 96	1100	16,000
Rapides Parish						
Woolf & Magee Inc	12	gas-btne	275	Beth S-45	275	10,000/2⅞"
Richland Parish						
Big Chief Drlg Co	29	gas	1875	Emsco 1250	1815	16,000
Sabine Parish						
Barnwell Drlg Co Inc	11	dsl	800	Wisn Rdair	800	12,000
St. Charles Parish						
Delta Drlg Co	32	stm	1200	Ideco Big Gnt	1690	15,000
Penrod Drlg Co	Bge 42	dsl	—	Brwstr N-12A	—	18,000
Wheless Drlg Co	15	dsl	1975	Natl 130	1455	16,000
St. James Parish						
Delta Drlg Co	31	gas-btne	1020	Emsco J-1000	1260	13,000
St. John The Baptist Parish						
Crown Rigs Inc	Bge 2	dsl	1000	Beth MC-450	1000	11,500
The Power Rig Drlg Co	4	gas-btne	700	M-CSCO U-15	—	10,000
St. Landry Parish						
A W Eggleston Inc	3	dsl	900	Ideco PR-1050	900	14,000
Mac Drlg Co	3	stm	600	Natl 23-9-FE	1000+	20,000
St. Martin Parish						
Delta Drlg Co	38	stm	530	Natl 239-S	1135	12,000
Gracey-Hellums Corp	Bge 2	stm	1200	Natl 23-9-FE	1200	15,000
Howell & Howell	5	gas	—	M-CSCO U-15	—	9,500
Prince Marine Drlg & Expl Co	2	dsl	1850	"Oilwell" 96	1500	16,000
St. Mary Parish						
Circle Drlg Co Inc	Bge 6	dsl-elec	2300	Ideco E2500	2750	20,000
Continental Drlg Co	6	dsl	650	Emsco GB-500	650	11,000
Delta Drlg Co	19	stm	1200	Natl 34-10-FE	1690	15,000
Falcon Seaboard Drlg Co	2	stm	1200+	Ideco Big Gnt	2000+	20,000
Buster Gardner Drlg Co Inc	2	dsl	—	Beth Tornado	—	15,000
C G Glasscock Drlg Co	6	dsl	1660	Natl 110	—	16,000
Hawkins-Wilkins Prod Co	2	dsl	—	Ideco PR-1050	900	15,000
Kelly Drlg Co Inc	1	stm	600	Ideco Jr Gnt	1200	15,000
Nicklos Drlg Co	18	gas-btne	—	Natl 110	1600	17,000
Norton Drlg Co	Bge 3	stm	1200+	Natl 34-62	1500	17,000
Penrod Drlg Co	Bge 46	dsl-elec	1250	Emsco ECB	1250	20,000
	Bge 50	dsl	—	Emsco EDES	1250	20,000
	Bge 52	dsl	—	Emsco EDES	1200	20,000
Salt Dome Prod Co	Bge 3	dsl	750	Natl 100	1000	12,500
Southeastern Drlg Corp	21-Bge 7	dsl	1200	"Oilwell" 96	1600	18,000
Wheless Drlg Co	Bge 14	dsl	1300	Emsco J-1400	1400	16,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Tensas Parish						
Big Chief Drlg Co	31	gas	1545	Emsco 800	1515	13,500
Jett Drlg Co Inc	107	dsl	600	Brwstr N-45	400	7,000
	109	gas-gaso	1000	Brwstr N-7	800	9,500
	112	dsl	1200	Brwstr 55	800	9,000
Justiss-Mears Oil Co Inc	8	gas	650	Emsco GA-500	560	11,000
Keoughan Drlg Co Inc	1	dsl	520	Crdwll O	—	8,500
Terrebonne Parish						
Brewster-Bartle Drlg Co Inc	7	dsl	—	"Oilwell" 96	1500	16,000
	8	dsl	—	"Oilwell" 96	1500	16,000
	11	dsl	—	"Oilwell" 96	1500	16,000
Columbia Drlg Co	Bge 1	dsl	800	"Oilwell" 76	750	12,000
Continental Marine Expl Co	Bge 11	dsl	975	"Oilwell" 96	975	14,500
Continental Shelf Drlg Corp	Belle Claire	dsl	1700	Beth 1013	1950	18,000
Crown Rigs Inc	Bge 1	dsl	1200	Beth 1013	1200	15,000
Delta Drlg Co	16	dsl	1200	Beth MC-950	1400	15,000
	37	dsl	900	Beth MC-950	1400	15,000
Dixie Drlg Co Inc	Bge 4	dsl	1350	Beth	1500	17,500
Doc Drlg Corp	Bge					
Blackie Drlg Co Inc	NEVA	dsl	1500	Beth 1013	1500	18,000
Neva-Andre Drlg Corp						
C G Glasscock Drlg Co	2	dsl	1200	Natl 80-B	—	12,000
	14	dsl	1500	Natl 75	900	12,000
Gracey-Hellums Corp	Bge 3	dsl	1775	M-CSCO U-1220	800	20,000
Grey Wolf Drlg Co	2	dsl-elec	1250	Alco BIW 12	1250	15,000
Kelly Drlg Co Inc	2	pwr	600	"Oilwell" 96	1500	18,000
	3	pwr	825	"Oilwell" 96	1500	18,000
Nicklos Drlg Co	12	stm	—	Natl	—	17,000
Norton Drlg Co	Bge 5	dsl	1200	"Oilwell" 96	1200	17,000
Penrod Drlg Co	Bge 40	dsl	—	—	1095	12,000
	Bge 45	dsl	—	—	1500	20,000
The Power Rig Drlg Co	Bge 6	gas-btne	800	Emsco GB-500	—	11,000
Rowan Drlg Co Inc	Bge 3	dsl-elec	2150	Emsco EDA	3455	20,000
	Bge 13	dsl-elec	1700	Emsco FCA	2700	18,000
	Bge 18	stm	1800	Emsco ED	750	18,000
	Bge 20	dsl	1120	Natl 75	1300	12,000
C B Webster Drlg Co	4	stm	1200	Natl FE-34-10	1200+	15,000
	5	stm	1350	Natl FE-23-10½	1200+	15,000
Wheless Drlg Co	7	stm	1000+	Emsco UBLS	1000+	15,000
	Bge 8	dsl	1300	Natl 130	1455	16,000
Union Parish						
Monroe Drlg Co Inc	1	stm	260	Natl U-2	—	12,000
Wheless Drlg Co	13	gas-btne	700	Emsco J-750	750	10,500
Vermilion Parish						
Brewster-Bartle Drlg Co Inc	2	dsl	—	"Oilwell" 96	1500	16,000
	14	dsl	—	Natl 125	—	16,000
Clegg & Hunt	6	stm	—	Natl 9-DMB	—	14,000
Comet Drlg Co	1	stm	1200	Ideco Big Gnt	—	16,000
Delta Drlg Co	5	gas-btne	900	Natl 100	800	12,000
Dixie Drlg Co Inc	1	dsl	1350	Beth	1500	17,500
	3	gas	1350	Beth	1800	17,500
A W Eggleston Inc	1	gas-btne	600	Natl 60A	600	9,500
	2	gas-btne	700	Ideco PR-800	700	10,500
Falcon Seaboard Drlg Co	1	stm	1200+	Ideco Big Gnt	2000+	20,000
	3	stm	1000+	Alco BIW 12	1200+	17,000
	29	stm	1200+	Natl 3410 FE	2000+	20,000
Grey Wolf Drlg Co	3	stm	1050	Alco BIW 12	—	13,500
Win Hawkins Drlg Co	5	dsl	200	Ideco PR 1050	900	15,000
Nicklos Drlg Co	10	stm	—	Natl	—	17,000
	14	gas-btne	—	Natl 75	1000	12,000
Norton Drlg Co	Bge 4	dsl	1400	Emsco J-1250	1500	17,000
Sunnyland Contr Co Inc	12	dsl	1120	Ideco H-525 SC	1000	10,000
Carnes W Weaver Drlg Co	Bge 1	dsl	2000	"Oilwell" 96	1700	16,000
	3	gas-btne	700	"Oilwell"	—	10,500
C B Webster Drlg Co	7	stm	1600	Emsco ECA-10½	1200+	15,000
Webster Parish						
H & S Drlg Co	1	gas-btne	1000	Wisn Titan	1000	12,000
Penrod Drlg Co	11	gas	—	—	1425	12,000
	35	stm	—	—	—	15,000
Williams Drlg Co Inc	1	dsl	278	Wisn Mogul	172	4,000
Woolf & Magee Inc	1	stm	1000+	Natl 34-10FE	1200+	15,000
	8	gas-btne	1300	Beth Tornado	1300	15,000
West Baton Rouge Parish						
Prince Marine Drlg & Expl Co	4	gas	1600	Emsco J-1100	1400+	15,000
Winn Parish						
Barnwell Drlg Co Inc	45	dsl	800	Brwstr N-45-M	650	8,000
MICHIGAN						
Allegan County						
Gordon Drlg Co	1	gas-LPG	250	"Oilwell" 64	225	4,000
	3	gas-LPG	500	"Oilwell" 64-B	400	5,000
	7	gas-LPG	500	"Oilwell" 64-B	400	5,000
D B Lesh Drlg Co	2	dsl	320	Natl T-25	320	5,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Hillsdale County						
Gordon Drlg Co	12	dsl	600	Wisn Giant	550	10,000
Mason County						
Bernhardt Drlg Co	1	dsl	300	Failing 2500	300	3,500/2⅛"
Osceola County						
Gordon Drlg Co	11	dsl	600	Wisn Rdair	500	10,000
Shiawassee County						
Gordon Drlg Co	8	gas-LPG	600	Natl 50-A	500	9,000
MISSISSIPPI						
Adams County						
Sunnyland Contr Co Inc	7	dsl	—	Ideco H-40	450	8,000
Wilson Drlg Co Inc	1	dsl	212	Ideco H-35-D	424	8,500/3½"
Woolf & Magee Inc	11	gas-btne	275	Beth S-45	275	10,000/2⅛"
Claiborne County						
Rowan Drlg Co Inc	30	dsl	1545	Emsco A-1500	1545	20,000
Clarke County						
Dorris Ballew Inc	4	dsl	760	Wisn Titan	1900	15,000
Clay County						
Drlg & Expl Co of Del Inc	37	gas-gaso	1200	Emsco GB-800	970	12,000
Greene County						
Dorris Ballew Inc	8	dsl	1380	Natl 125	1725	16,000
Jett Drlg Co Inc	106	dsl	1600	Brwstr N-95	1400	13,000
Hancock County						
Marshall R Young Drlg Co	12	—	740	Natl 50-A	558	10,000
Hinds County						
Larco Drlg Co	5	gas	800	"Oilwell" 76	1000	10,000
	7	gas	900	"Oilwell" 96	1000	12,000
Jefferson Davis County						
Drlg & Expl Co of Del Inc	39	gas-gaso	1200	Emsco J-1100	1050	15,000
Hawkins-Wilkins Prod Co	1	stm	—	Natl 34-10 FE	—	15,000
Jett Drlg Co Inc	105	dsl	600	Natl T-32	500	8,000
Jones County						
Cook Drlg Co	20	gas-btne	900	Wisn Titan	975	12,500
Justiss-Mears Oil Co Inc	9	gas	650	Emsco GA-300	560	11,000/4"
A W Williams Drlg Co Inc	2	dsl	495	Frnks 6000	495	8,500/4"
Lamar County						
Gulf Coast Drlg & Expl Inc	4	dsl	800	Natl T-32	800	6,500
Lincoln County						
Dorris Ballew Inc	1	dsl	760	Wisn Titan	1300	12,500
	2	dsl	760	Wisn Titan	1300	12,500
Dixilyn Drlg Corp	1	gas	900	Natl 75	650	12,000/3½"
Drlg & Expl Co of Del Inc	23	gas-gaso	1000	Natl 100	900	12,000
Gulf Coast Drlg & Expl Inc	3	dsl	900	Natl 80-B	900	12,500
Marshall R Young Drlg Co	6	stm	1688	Natl 34	1480	16,000
	7	stm	1688	Natl 34	1480	16,000
	8	—	1350	Wisn Titan	1122	14,000
Marion County						
Win Hawkins Drlg Co	4	stm	—	Natl 34-10-FE	—	15,000
Marshall R Young Drlg Co	5	—	1350	Wisn Titan	1122	14,000
Monroe County						
A W Williams Drlg Co Inc	1	dsl	186	Joy 300	200	5,500/2⅛"
Pearl River County						
Crawford Drlg Co	3	stm	—	"Oilwell" 96	500	10,500
Gulf Coast Drlg & Expl Inc	1	dsl	900	Natl 80-B	900	12,500
Justiss-Mears Oil Co Inc	7	dsl	700	Emsco J-750	1000	11,500
Pike County						
Dixilyn Drlg Corp	5	gas	950	Natl 100	950	14,000
Rankin County						
Arrow Drlg Co	5	gas	1250	Emsco	—	14,000
Jett Drlg Co Inc	111	dsl	2000	Natl 110	1500	15,000
Scott County						
Dixilyn Drlg Corp	6	dsl	2490	Natl 130	2490	16,000
Zach Brooks Drlg Co	8	gas	2600	Brwstr N-12	2600	18,000
Jett Drlg Co Inc	110	dsl	1400	Brwstr N-95	1400	14,000
Larco Drlg Co	6	dsl	1200	"Oilwell" 96	1600	18,000
Smith County						
Zach Brooks Drlg Co	9	gas-btne	1350	Brwstr N-95	1350	14,000
Gulf Coast Drlg & Expl Inc	5	—	—	—	—	—
Larco Drlg Co	2	dsl	1200	"Oilwell" 96	1200	14,000
	4	dsl	1700	"Oilwell" 96	1600	18,000
Marshall R Young Drlg Co	11	—	1350	Wisn Titan	1122	14,000
Stone County						
Drlg & Expl Co of Del Inc	41	gas-gaso	1500	Emsco J-1100	1050	15,000
Walthall County						
Gulf Coast Drlg & Expl Inc	2	dsl	1200	Natl 110	1200	14,000
Wayne County						
Cook Drlg Co	16	gas-btne	1050	Wisn Titan	975	12,500
Justiss-Mears Oil Co Inc	1	dsl	350	Emsco GB-800	900	13,000
Marshall R Young Drlg Co	3	—	900	Natl 75	830	11,500
Wilkinson County						
Woolf & Magee Inc	10	gas-btne	275	Beth Breeze	275	10,000/2⅛"
Yazoo County						
Woolf & Magee Inc	7	gas-btne	800	Beth MC-450	800	11,000
MONTANA						
Carbon County						
True Drlg Co	9	gas-gaso	1200	M-CSCO U-40	1200	11,000
Carter County						
Roden & McRae Drlg Corp	4	dsl	900	Emsco GB-800	900	12,500
Dawson County						
J D Sprecher	2	dsl	900	Emsco J-750	900	9,500
Fallon County						
Zach Brooks Drlg Co	6	dsl	1300	Brwstr N-75	1300	12,500
Hewit-Gulick Drlg Co	2	dsl	970	Natl 80	900	12,000
Roden & McRae Drlg Corp	3	dsl	900	Emsco GB-800	900	12,500
Glacier County						
Anschutz Oil Co Inc	6	dsl	300	Wisn Gnt	280	5,500
Meagher County						
Hose-Austin Drlg Corp	2	dsl	300	Natl T-32	320	5,000
Musselshell County						
Fitzpatrick Drlg Co Inc	3	dsl-btne	300	Natl T-20	200	5,500
Hose-Austin Drlg Corp	1	dsl	350	Emsco GB-250T	450	6,000
Roosevelt County						
Zach Brooks Drlg Co	3	dsl	900	Brwstr N-7	900	8,500
Hose-Austin Drlg Corp	4	gas	500	Emsco GB-350	588	7,500
Rosebud County						
Fitzpatrick Drlg Co Inc	2	dsl	500	M-CSCO U-22	500	6,500
Olen Oil Corp	3	dsl	500	Natl T-20	280	5,000
Sheridan County						
Helmerich & Payne Inc	33	gas	850	"Oilwell" 76	1100	11,000
Teton County						
Anschutz Oil Co Inc	11	gas	1000	Wisn Giant	700	8,500
Wibaux County						
Helmerich & Payne Inc	15	dsl	975	"Oilwell" 76	1000	11,000
Signal Drlg & Expl Inc	5	gas-btne	—	Natl 80	1400	14,000
NEBRASKA						
Banner County						
Garvey Drlg Co	16	dsl	300	Wisn Roadair	450	7,000/3½"
Lewis Bros Inc	3	dsl	376	M-CSCO U-15	476	8,000
McDaniel Drlg Co	1	dsl	350	Ideco H-40	350	6,000
Dawes County						
Earl F Wakefield	5	gas-btne	550	Wisn Gnt	550	6,500
Hayes County						
Earl F Wakefield	3	dsl	440	Wisn Gnt Rdair	440	6,000
Hitchcock County						
Brack Drlg Co Inc (Colo)	4	dsl	—	M-CSCO U-10	254	5,500
Kimball County						
Ashby Drlg Co Ltd	2	dsl	300	Natl T-20	300	8,000/3½"
Baird & Pfeifer Drlg Co	2	gas	500	M-CSCO U-15	—	7,500
Exploration Drlg Co	1	gas	470	Beth S-60	500	8,000
Falcon Seaboard Drlg Co	20	gas-btne	425	M-CSCO U-15	425	8,500
Garvey Drlg Co	20	dsl	300	Wisn Mogul 42	450	7,000/3½"
Herndon Drlg Co	3	gas	600	Natl 50	750	8,000
Don Johnston Drlg Co	4	gas-btne	650	Natl 50	650	7,500
Lewis Bros Inc	1	dsl	376	Crdwll J-450	476	7,500
	2	btne	360	M-CSCO U-15	460	6,500
Miracle-Fifer Drlg Co	1	btne	300	M-CSCO U-15	660	8,500
Murfin Drlg Co	5	dsl	450	Emsco 500	520	9,000
Merrill County						
Herndon Drlg Co	2	gas	600	Natl 50-A	750	10,500
Richardson County						
Nemaha Oil Co	1	dsl	370	Frnks SAL 3000	370	4,500/3½"
NEVADA						
Nye County						
John S Hagestad Drlg Co	2	dsl	540	Ideco H30-D	540	4,500
NEW MEXICO						
Chaves County						
A W Thompson Inc	9	gas	650	Clark Pr-1000	1050	13,500
Eddy County						
Great Western Drlg Co	40	gas	450	Wisn Atlas	840	10,000
Johnn Drlg Co	6	gas	850	Brwstr N-95	1300	14,000
Carl B King Drlg Co of Tex	12	gas-gaso	1000	Natl 75	1000	12,500
Lee Drlg Co	4	gas-gaso	700	Natl 75	—	10,000
Parker Drlg Co	45	gas	—	Natl 125	1400	15,000
Rowan Drlg Co Inc	7	gas-btne	1260	Natl 100	1680	14,000
	12	gas-btne	1260	Natl 100	1680	14,000
	28	gas-btne	1300	Natl 125	1530	15,000
Urice Drlg Co	6	gas-btne	280	Wisn Super	145	3,000
S P Yates Drlg Co	2	dsl	350	M-CSCO U-15	540	6,500
	3	dsl	350	Natl T-12	250	4,000
Hidalgo County						
Durham Drlg Co Inc	4	gas	1250	Ideco 7-11	1450	15,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Lea County						
Alan Drlg Co	2	gas	350	Wisn Mogul	185	4,000
Bickerstaff & Tibbets Drlg Co	7	gas	450	Emsco G-36	450	6,000
Cactus Drlg Corp of Tex	1	gas-btne	1575	Natl 110	1575	15,000
	4	gas-btne	1050	"Oilwell" 76	1050	12,500
	5	gas-btne	700	Natl 75	700	10,000
	7	gas-btne	1275	"Oilwell" 96	1050	15,000
	11	gas-btne	300	Brwstr N-4	460	5,000
Calco Drlg Co	1	gas-btne	225	Mayhew 3000	200	3,500
	6	dsl	300	Beth S-45E	250	5,500
Carper Drlg Co Inc	4	gas-btne	650	Beth S-55	560	6,000
	5	gas-btne	675	M-CSCO U-15	675	8,000
Clark Dale Drlg Co Inc	1	gas	—	"Oilwell" 76	1000	12,500
Davidson Drlg Co Inc	C	btne	660	Emsco GC-500	660	8,500
Delta Drlg Co	6	gas-btne	800	Emsco J-750	750	9,500
	9	gas-btne	936	Natl 100	800	12,000
Denver Drlg Corp	2	gas	550	Natl 50	550	8,500
	4	gas	440	Natl 50	440	8,000
Durham Drlg Co Inc	1	gas	500	M-CSCO U-15	660	8,500
	3	gas	1150	M-CSCO U-20	1300	14,000
Helmerich & Payne Inc	25	gas	1100	"Oilwell" 96	1100	14,000
	32	gas	1100	"Oilwell" 96	1100	14,000
Highland Drlg Co	2	gas	325	Ideco H-35	375	5,600
Kerr-McGee Oil Ind Inc	7	gas	900	Natl 75	818	11,500
Carl B King Drlg Co of Tex	7	gas-gaso	1000	Natl 100	1000	13,500
	20	gas	2100	"Oilwell" 96-16	2100	20,000
La Mance Drlg Co	1	btne	350	Frnks 5000	—	5,000
Llano Drlg Co	5	gas	—	Natl 100	1050	14,000
Chas E Long Jr Inc	1	gas	200	M-CSCO U-10	400	6,000
Lowe Drlg Co	2	gas	750	Natl 75	750	10,000
	4	gas	1800	Natl 125	1800	17,500
	8	gas	1500	Natl 80	1500	15,000
	9	gas	2000	Natl 125	2000	17,000
	10	gas	1000	Wilson	1000	12,500
	11	gas	1250	Natl 100	1250	12,500
Marcum Drlg Co	2	gas-btne	500	M-CSCO U-15	675	8,000
	4	gas-btne	325	Brwstr 55-W	450	6,000
McAlester Fuel Co	2	btne-gas	—	Natl 100	1050	14,000
	5	btne-gas	—	Emsco J-1100	1050	14,000
McQueen & Stout Drlg Co	15	LPG	225	Crdwll RL	185	4,500
Moran Oil Prod & Drlg Corp	2	gas	—	Natl 75	750	10,000
	3	gas	—	M-CSCO U-15	800	8,500
	4	gas	—	M-CSCO U-34	300	5,000
R Olsen	4	gas	1101	Wisn Titan	1101	12,500
Parker Drlg Co	42	gas	—	Natl 100	1400	14,000
	49	gas	—	Natl 125	1400	15,000
	51	gas	—	Natl 50	700	9,000
	52	gas	—	"Oilwell" 76	1400	12,500
Sharp Drlg Co	18	gas	1350	Beth MC-950	1350	15,000
	46	dsl	1500	Natl 125	1500	18,000
A W Thompson Inc	2	gas	650	Beth 10-13	1650	16,000
	3	gas	650	Emsco 800	1050	13,500
	4	gas	650	Beth 810	1050	13,500
	12	gas	350	Emsco 350	600	7,000
Tri-Service Drlg Co	6	gas	1350	"Oilwell" 96	1350	16,000
Western Drlg Co Inc	16	dsl	600	Emsco 350	290	6,000
	21	btne	650	Natl 100	325	10,000
	8	gas-btne	600	Beth MC-650	700	11,000
	11	gas-btne	1000	Beth 810	1100	11,000
Westlund Drlg Co	3	gas-btne	600	M-CSCO U-15	—	8,500
S P Yates Drlg Co	1	dsl	380	M-CSCO U-34	350	5,000
Rio Arriba County						
Arapahoe Drlg Co	1	gas-btne	300	Natl T-32	320	6,000
	3	gas-btne	300	Wisn Mogul	275	5,000
Brannon & Murray Drlg Co	1	gas-LPG	550	Brwstr N-55	550	8,500
Carroll Drlg Co Inc	10	gas-btne	—	Emsco	—	9,500
D-K Drlg Co	2	gas	675	Natl 50	675	7,500
Empire States Drlg Corp	1	gas	225	M-CSCO U-34 Trlr	225	5,000
Fleeger Drlg Inc	1	dsl	325	Beth Twister	600	8,500
	6	dsl	450	M-CSCO U-15	600	8,500
	7	dsl	360	Beth 45-E	500	5,000
Great Western Drlg Co	31	gas-gaso	307	M-CSCO U-15	840	9,000
	32	gas	353	M-CSCO U-15	750	7,500
Moran Bros Inc	10	gas	400	Emsco GA-350	550	8,000
Nichlos Drlg Co	3	gas-btne	700	Natl 50-A	700	9,000
Roosevelt County						
Frank Frawley Drlg Co	2	gas	—	M-CSCO U-20	1050	13,000
Lowe Drlg Co	1	gas	500	M-CSCO U-15	500	7,500
San Juan County						
Anschultz Oil Co Inc	2	dsl	900	Wisn Gnt	560	8,500
Brannon & Murray Drlg Co	2	gas-LPG	550	Emsco GA-350	550	6,500
	3	gas-LPG	350	Brwstr N-4	250	5,000
Carroll Drlg Co Inc	6	dsl	—	M-CSCO U-15	—	6,500
	8	gas-btne	—	Natl 75	—	9,500
Empire States Drlg Corp	2	gas	530	Ideco H-35	530	6,500
	3	gas	225	Crdwll L	225	4,000
Exploration Drlg Co	4	gas	625	M-CSCO U-15	600	8,000
Fleeger Drlg Inc	5	dsl	360	Frnks	500	5,000
Forae Drlg Co	1	gas-btne	325	M-CSCO U-34	300	4,500
	3	gas-btne	325	M-CSCO U-15	600	7,500
	4	gas-btne	325	Emsco GA-500	500	7,500
	5	btne	350	"Oilwell" 52-T	426	6,000
Gardner Bros Drlg Co Inc	9	gas-btne	450	M-CSCO U-15	675	7,000
	17	gas-btne	550	Natl 50-A	700	8,500
Great Western Drlg Co	36	gas-gaso	320	M-CSCO U-15	675	7,500
Herndon Drlg Co	4	gas	480	Emsco G-450	630	7,000
H B Lynn Drlg Corp	1	gas-btne	700	Natl 50	—	7,500
	2	gas-btne	700	Natl 50	—	7,500
	3	gas-btne	700	Natl 50	—	7,500
Miracle-Fifer Drlg Co	2	btne	300	M-CSCO U-15	760	8,500
	3	btne	300	M-CSCO U-34	420	6,000
San Juan Drlg Co	3	gas	570	Natl 50	570	7,500
	4	gas	570	Natl 50	570	7,500
	5	gas	213	Natl 40	213	5,000
	8	gas	570	Natl 50	570	7,500
	10	gas	570	Natl 50	570	7,500
	12	gas	213	Brwstr 70	213	4,000
	14	dsl	340	Frnks SA-4500	400	5,000
	15	gas	570	M-CSCO U-15	570	7,500
Schafer Drlg Co	4	gas-gaso	200	M-CSCO U-34	200	6,000
Signal Drlg & Expl Inc	6	gas-btne	1000	M-CSCO U-40	1000	13,500
NEW YORK						
Steuben County						
Delta Drlg Co	39	gas-btne	500	Natl 75	1000	9,500
Tompkins County						
Gordon Drlg Co	S-7	dsl	300	Crdwll S	300	4,500
NORTH DAKOTA						
Sharp Drlg Co	45	gas	800	Natl T-20	300	5,000
Billings County						
Helmerich & Payne Inc	29	gas	950	Natl 75CA	1100	11,000
Bottineau County						
Anachutz Oil Co Inc	5	dsl	300	Wisn Gnt	280	5,500
Calvert Drlg Inc	22	gas-btne	320	Ideco H-35	330	5,500
	24	gas-btne	600	M-CSCO U-15	600	9,000
Cardinal Drlg Co (Bismark)	1	dsl	320	Emsco GB-250	320	5,500
	2	dsl	320	Natl T-20	320	5,000
	3	dsl	280	Frnks	280	3,000
	—	dsl	320	Natl T-20	320	5,000
Burke County						
Brinkerhoff Drlg Co Ltd	2	dsl	370	Natl 50-A	600	8,000
Cactus Drlg Corp Ltd	2	gas-btne	675	M-CSCO U-15	675	8,500
Calvert Drlg Inc	25	gas-btne	1050	Beth 810	1100	12,500
Exploration Drlg Co	6	gas	310	Beth S-50	200	5,500
Hose-Austin Drlg Corp	3	gas	450	M-CSCO U-15	550	7,000
Penrod Drlg Co	19	dsl	—	—	730	9,000
Signal Drlg & Expl Inc	2	dsl	370	M-CSCO U-36-A	420	7,500
	3	dsl	370	M-CSCO U-36-A	420	7,500
Divide County						
Cactus Drlg Corp Ltd	1	gas-btne	450	Brwstr N-55	450	7,000
Calvert Drlg Inc	23	dsl	350	Ideco H-525	600	8,500
McHenry County						
Exploration Drlg Co	9	gas	310	Beth S-50	250	5,500
McKenzie County						
Anschutz Oil Co Inc	14	gas	900	Brwstr N-7	600	10,000
Calvert Drlg Inc	26	gas-btne	1380	Natl 80-B	1380	14,000
Penrod Drlg Co	31	dsl	—	—	1200	10,000
Rowan Drlg Co Inc	5	gas-btne	840	Natl 75	1120	11,000
	15	gas-btne	1140	Natl 75	1503	11,000
	23	gas-btne	1140	Natl 75	1503	11,000
Mountrail County						
Anschutz Oil Co Inc	12	gas	830	Brwstr N-45	530	7,000
Stark County						
Anschutz Oil Co Inc	15	dsl	1000	"Oilwell" 76	1000	12,000
Williams County						
Helmerich & Payne Inc	8	gas	600	Natl 55	800	9,000
Rowan Drlg Co Inc	27	gas-btne	1350	Natl 125	1530	15,000
OHIO						
Meuree County						
D J Branyan Co	1	dsl	600	Wichtex E-75	145	3,000

OKLAHOMA

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Alfalfa County						
Barrett Petroleum Co	2	gas-gaso	—	Natl 50	450	6,800
Davon Drlg Co	1	gas-LPG	250	Brwstr N-4	300	6,000
	5	gas-LPG	400	Brwstr N-45	320	7,500
Dudley & Heath Drlg Co	7	dsl	265	Brwstr N-4	320	5,500
Garr-Woolley Co	2	gas-btne	255	Emsco 350	378	7,000
Viersen & Cochran	12	gas	325	Natl T-25	225	5,500
Webster Drlg Co	5	gas-btne	450	Natl 50	450	7,500
Atoka County						
Jet Drlg Co Inc	6	gas-btne	1400	Brwstr N-95	1200	15,000
Beaver County						
Arrow Drlg Co	11	dsl	595	Emsco 500	—	8,000
	20	gas	460	Emsco 350	—	7,000
Big Chief Drlg Co	27	gas	760	JS&G Spad Spr	760	9,000
N V Duncan Drlg Co	2	gas	600	"Oilwell" 64-B	600	9,000
Luke Grace Drlg Co	10	dsl-gas	600	Wisn Gnt	600	8,500
Harper-Turner Drlg Co	1	gas	650	Wisn Titan	—	11,000
Helmerich & Payne Inc	36	gas	500	Emsco GB-500-52	700	9,000
	46	gas	500	Emsco GB-500-52	700	9,000
Lynn Drlg Co	1	gas-btne	300	Natl 50	450	7,000
	5	gas-btne	725	Natl 75	900	10,500
Midwestern Drillers Inc	3	dsl	370	M-CSCO U-15	750	8,500
	7	dsl	370	M-CSCO U-15	750	8,500
Moran Bros Inc	6	gas	700	Wisn Gnt	750	9,500
Musgrove Petroleum Corp	2	dsl	495	Emsco 350	—	7,000
Viersen & Cochran	1	gas	325	Natl 150	450	8,800
	5	gas	500	Natl 50	650	9,000
Wagner & Wyant Drlg Co Inc	1	dsl	300	M-CSCO U-15	450	8,000
Earl F Wakefield	6	dsl	960	Wisn Atlas Rdair	960	13,000
Webster Drlg Co	6	gas-btne	600	Beth	600	7,500
Beckham County						
Big Chief Drlg Co	36	gas	800	Natl 55	800	11,000
Helmerich & Payne Inc	47	gas-btne	2000	"Oilwell" 96-16	2000	20,000
Parker Drlg Co	57	gas	—	Natl FE 23-X10	1800	18,000
Caddo County						
Arrow Drlg Co	25	gas	840	Ideco 1000	—	10,000
Graham Drlg Co (Okla)	1	gas-btne	235	Wisn Mogul	285	5,000
Harper-Turner Drlg Co	9	gas	125	Crdwll	—	4,000
Helmerich & Payne Inc	38	gas	950	Natl 80	1100	11,000
Slats Honeymon Drlg Co	2	gas-btne	450	Natl 80-A	—	12,000
Howell & Howell	9	gas	1600	Emsco A-1500	2500	25,000
Parker Drlg Co	34	gas	—	Natl 75	800	10,000
G H Ray Well Serv	1	prop-gas	200	Wilson	200	4,500
Sherin Drlg Co	3	gas-gaso	500	M-CSCO U-15	600	8,000
Viersen & Cochran	2	gas	500	Natl 55	650	10,500
Carter County						
Berry Drlg Co	1	dsl	350	Wisn Gnt	500	6,500
N V Duncan Drlg Co	7	gas	250	Natl 50	450	7,500
Frankfort Oil Co Drlg Div	4	gas	1200	Brwstr N-95	—	16,000
	5	gas	800	Brwstr N-75	—	10,000
Glenn Gillespie & Sons	7	dsl	300	Frnks 658 TRD	225	4,000
Goff-Leeper Drlg Co	2	gas	225	Brwstr N-4	350	6,000
Graves Drlg Co	1	dsl	300	Frnks 4000-A	330	3,500
	2	gas	185	Franks	125	2,000
B M McGraw Drlg Contr	1	gas-gaso	900	Brwstr N-7	900	8,000
	4	dsl	—	Frnks SAL-5000	400	5,000
Ward S Merrick	1	gas	300	Wisn Gnt	—	5,000
Sherin Drlg Co	2	gas-gaso	500	M-CSCO U-15	660	8,000
	5	gas-gaso	750	Natl 55	750	9,000
Star Drlg Co	1	dsl	104	Wisn Spr	104	2,000/3½"
Cimarron County						
Midwestern Drillers Inc	2	dsl	320	M-CSCO U-15	600	7,500
Cleveland County						
A & P Drlg Co Inc	2	gas-gaso-btne	500	Emsco GB-500	500	8,000
An-Son Drlg Co	2	gas	600	M-CSCO U-15	700	9,000
Davon Drlg Co	3	gas-LPG	500	Brwstr N-7	750	10,000
T T Eason Co Div Eason Oil Co	12	gas	1000	Natl 80-B	1060	12,500
	14	gas	750	Emsco 6-B-500	940	9,500
Flournoy-Haston Drlg Co Inc	3	gas	600	Wisn Atlas	750	10,000
Garr-Woolley Co	4	gas-btne	320	Emsco 500-GC	510	9,500
Goff-Leeper Drlg Co	3	gas	450	M-CSCO U-15	450	8,000
Harper-Turner Drlg Co	4	gas	450	Natl 50	—	7,500
Kirkpatrick Oil Co	4	gas	504	Wisn Giant	504	10,500
Coal County						
Sherin Drlg Co	4	gas-gaso	1000	Natl 10	1050	12,000
Cotton County						
C N P Drlg Co	1	gas	185	Wichtex	145	3,500
R Benton Ross Inc	1	dsl	225	Wilson	165	4,000
Creek County						
Mesker Drlg Co	2	gas	185	Joy 300	160	2,500
Unit Drlg Co	1	gas-btne	290	M-CSCO U-34	300	5,500
Custer County						
Big Chief Drlg Co	2	gas	1875	Natl 125	1815	16,000
Dewey County						
Falcon Seaboard Drlg Co	15	gas-btne	1100	M-CSCO U-20	1200	16,000
Ellis County						
Big Chief Drlg Co	24	gas	750	M-CSCO U-15	800	9,500
Keating Drlg Co	13	gas-gaso	—	—	1000	12,000
J S Montgomery	3	gas	1100	Natl 80	1100	12,000
Webster Drlg Co	9	gas-btne	—	Natl 100	1110	14,000
Garfield County						
Hayward Drlg Co	1	gas	200	Wilson	125	2,500
The Novak Drlg Co	3	gas	265	Brwstr N-45	—	5,000
Garvin County						
Big Chief Drlg Co	35	gas	2610	Natl 110	2610	16,000
Bryant-Hayward Drlg Co	2	gas	675	Natl 50	675	8,500
	3	gas	700	M-CSCO U-15	700	9,500
Dearing Inc	1	gas-btne	—	Natl 50	—	7,000
	2	gas-btne	—	Natl 100	—	15,000
	5	gas-btne	—	Wisn Gnt	—	6,000
N V Duncan Drlg Co	4	gas	600	Beth 450	600	9,000
Flournoy-Haston Drlg Co	2	gas-btne	300	M-CSCO U-15	650	8,500
	4	gas-btne	700	Natl 100	1000	14,000
Garvey Drlg Co	6	dsl	275	M-CSCO U-15	640	8,500
	21	dsl	500	M-CSCO U-15	640	8,500
Hap Drlg Co	1	gas	350	Emsco GB-500	550	8,000
Holliman Drlg Co	4	gas	255	M-CSCO U-15	500	7,500
Slats Honeymon Drlg Co	1	gas-btne	450	Natl 50-A	—	9,000
Tom Jack Drlg Co	1	dsl	200	Crdwll S-350	200	5,000/3½"
Kerr-McGee Oil Ind Inc	41	gas	970	Natl 75	832	11,500
Parker Drlg Co	5	gas	—	Natl 50	700	9,000
Perkins Bros Drlg Co	2	gas-btne	—	M-CSCO U-15	675	8,500
Sherin Drlg Co	1	gas-gaso	500	M-CSCO U-15	600	8,000
Viersen & Cochran	7	gas	600	Wisn Titan	650	10,500
Chester H Westfall Drlg Co	1	gas-gaso	625	M-CSCO U-15	700	10,400
Grady County						
A & P Drlg Co Inc	1	gas-gaso-btne	450	Emsco G-450	450	7,000
Falcon Seaboard Drlg Co	Z-3	gas-btne	1200	Beth 950	1600	18,000
Helmerich & Payne Inc	44	gas	1200	"Oilwell" 96	1500	15,000
Viersen & Cochran	9	gas	1200	Emsco J-1250	1590	18,000
Dick Wegener Drlg Contr	4	gas-dsl	1900	Natl 130	1900	22,000
Grant County						
Barrett Petroleum Co	4	dsl	—	M-CSCO U-10	350	5,800
Kirkpatrick Oil Co	1	gas	300	Beth S-60	258	7,500
Viersen & Cochran	6	gas	255	Natl T-25	225	5,500
	14	gas	325	Natl T-25	225	5,500
Harper County						
Arrow Drlg Co	1	gas	860	Ideco 1000	—	11,500
Barrett Petroleum Co	1	gas-gase	—	Natl 50	450	6,800
Calvert Drlg Co	19	dsl	350	M-CSCO U-15	600	8,500
	21	dsl	350	Ideco H-35	260	6,500/4"
T T Eason Co Div Eason Oil Co	15	gas	750	Emsco T-250	450	6,300
Falcon Seaboard Drlg Co	21	gas-btne	600	M-CSCO U-15	600	8,500
General Drlg Co	5	—	—	M-CSCO U-15	—	9,000
Harper-Turner Drlg Co	8	gas	480	Natl 50	—	8,000
Holm Drlg Co	6	dsl	750	Wisn Rdair	600	8,500
Carl B King Drlg Co of Tex	11	gas-gaso	900	Natl 75	900	11,000
Lynn Drlg Co	4	gas-btne	300	Natl 50	675	8,000
R W Rine Drlg Co	4	dsl	620	Brwstr N-75	750	9,500
Schafer Drlg Co	1	gas-gaso	1200	M-CSCO U-40	900	12,000
Hughes County						
Bodard Drlg Co	1	gas	225	M-CSCO	185	4,500
Johnston County						
Parker Drlg Co	55	gas-elec	—	Emsco 750	2000	10,000
Kay County						
Branyan Drlg Co	2	dsl	700	Beth	700	9,000
Hap Drlg Co	2	gas	300	Brwstr N-4	200	5,000
Herndon Drlg Co	1	gas	409	"Oilwell" 64-B	559	6,000
Dave Morgan Drlg Co	—	LPG-gas	350	Natl T-32	320	6,000
Reed Drlg Co Inc	6	gas-gaso	240	Natl T-12	180	4,500+
Target Drlg Corp	1	gas-btne	225	M-CSCO U-34	195	5,000
Lincoln County						
Dudley & Heath Drlg Co	6	dsl	265	Crdwll S	320	5,500
Folk Drlg Co	1	dsl	200	Crdwll RL	200	4,000
Garr-Woolley Co	3	gas-btne	320	Emsco 500-GB	510	9,500
R L Horn & Sons Drlg Co	3	gas	185	Brwstr N-3	165	5,000
Sabre Drlg Co	4	gas-LPG	225	Brwstr N-3	160	3,500/4"
Wolfe Drlg Co	12	gas-btne	342	Natl T-20	342	4,500
Logan County						
Big Chief Drlg Co	1	gas	450	JS&G Spad "Super"	450	6,500
Calvert Drlg Inc	15	dsl	260	Ideco H-35	260	5,000
Davon Drlg Co	2	gas-LPG	280	Brwstr N-4	320	6,500
Garr-Woolley Co	1	gas-btne	185	Emsco 300	280	5,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Nuckolls-Bell Drlg Co	2	dsl	300	Ideco H-40	352	7,500
Summit Drlg Corp	2	dsl	—	Frnks SAL 5000	800	5,000
Love County						
Arrow Drlg Co	18	gas	1260	Emsco 1250	—	14,000
Falcon Seaboard Drlg Co	24	gas-btne	1000	Beth 950	1365	16,000
	32	gas-btne	1050	Beth 650	1155	16,000
Nichols Drlg Co	77	gas-btne	1530	Natl 110	1530	18,000
Major County						
Calvert Drlg Inc	18	gas-btne	350	M-CSCO U-15	600	8,500
Parker Drlg Co	56	gas	—	Natl 50	700	9,000
Webster Drlg Co	4	gas-btne	750	Emsco 500	750	8,500
Marshall County						
Bolin Oil Co & D H Bolin	5	gas	225	Wisn Mogul	190	4,000
McClain County						
Falcon Seaboard Drlg Co	8	gas-btne	450	Beth 450	900	10,000
	28	gas	1200	Beth 650	1050	16,000
Fleeger Drlg Inc	2	dsl	320	Wisn Rdair	700	8,500
Goff-Leeper Drlg Co	1	gas	800	Brwstr N-75	800	12,000
	4	gas	850	Wisn Gnt	850	12,500
Helmerich & Payne Inc	24	gas	950	Natl 80	1100	11,000
Holliman Drlg Co	5	dsl	825	Emsco GB-800	1000	11,000
	6	gas	750	Wisn Atlas	950	10,000
Nichols Drlg Co	2	gas-btne	700	Natl 55	1050	12,000
	9	gas-btne	700	Natl 50-A	700	10,000
Nuckolls-Bell Drlg Co	3	dsl	600	Ideco H-525	704	9,000
Parker Drlg Co	37	gas	—	Natl 100	1400	14,000
	38	gas	—	Natl 100	1000	14,000
Perkins Bros Drlg Co	4	gas-btne	1200	Beth 650	1200	12,000
Viersen & Cochran	3	gas	600	Natl 75-CA	650	10,500
	4	gas	600	Natl 75	650	10,500
	8	gas	980	Emsco J-1000	975	14,000
Chester H Westfall Drlg Co	2	gas-gaso	625	M-CSCO U-15	700	10,400
	3	gas-gaso	625	M-CSCO U-15	700	10,400
McIntosh County						
Reed Drlg Co Inc	4	gas-gaso	300	M-CSCO U-34	290	5,000
Murray County						
Frankfort Oil Co Drlg Div	3	gas	900	Brwstr N-75	—	10,000
Noble County						
Chambless-Rosen Drlg Co	1	gas-btne	225	Crdwll RL	200	5,000
Summit Drlg Corp	3	gas	—	Emsco 450	450	7,000
Unit Drlg Co	3	dsl	700	Natl 50-A	700	6,500
Okfuskee County						
Doak Drlg Co	2	btne-gas	270	Natl T-20	250	4,500
Johnson-Bates Drlg Co	2	gas	300	M-CSCO U-34	300	5,000
Sabre Drlg Co	2	dsl	330	M-CSCO U-34	300	5,000/4"
Oklahoma County						
Brewster-Bartle Drlg Co Inc	15	gas	—	Emsco	—	10,000
C H & C Drlg Co	1	gas	300	M-CSCO U-15	680	9,000
Davon Drlg Co	4	gas-LPG	200	Brwstr N-2	290	6,500/2⅛"
Falcon Seaboard Drlg Co	26	dsl	225	Beth Twister	212	6,500
Harper-Turner Drlg Co	2	gas	450	Natl 50	—	7,500
	3	gas	450	Natl 50	—	7,500
Viersen & Cochran	13	gas	325	Natl T-16	175	5,200
Okmulgee County						
Smallwood & Son	1	gas-btne	145	Failing 1500	130	1,750
Twinoak Drlg Co	1	dsl	190	Frnks	190	3,500
Wade Drlg Co Inc	1	dsl	225	Crdwll L	185	3,500
Osage County						
Delaware Drlg Co	3	dsl	160	Crdwll AL	150	4,000/2⅛"
Doak Drlg Co	3	btne-gas	270	Natl T-20	250	4,500
Falcon Seaboard Drlg Co	19	gas-btne	185	M-CSCO U-34	194	5,000
Glenn Gillespie & Sons	1	gas	360	M-CSCO U-34	225	4,500
	6	gas	290	M-CSCO U-34	290	4,500
John Heard & Co Inc	2	gas-LPG	270	Natl T-12	212	3,500
R L Horn & Sons Drlg Co	2	dsl	185	Frnks Sr Clpr	185	4,000
Al Johnson Drlg Co	2	btne	325	Mayhew	200	3,500
Mesker Drlg Co	1	gas	214	Joy 300	170	2,500
The Novak Drlg Co	1	gas	225	Brwstr N-4	—	3,500
Overby Drlg Co Inc	2	dsl-btne	250	Mayhew 2000	—	2,500
Reed Drlg Co Inc	3	gas-gaso	180	M-CSCO U-34	180	3,200
Pawnee County						
John Heard & Co Inc	1	gas-LPG	240	Brwstr N-4	212	3,500
Pete Morris Drlg Co	1	dsl-gas	550	Wisn Gnt	550	6,000
Reed Drlg Co Inc	1	gas-gaso	220	M-CSCO U-34	235	5,000
Payne County						
Curt Brown Drlg Co	1	dsl	320	Frnks Comet	320	5,000
	2	dsl	320	Frnks Comet	320	5,000
Foster Drlg Co Inc	1	dsl	265	Natl T-16	265	5,000
Glenn Gillespie & Sons	2	gas-dsl	360	Wisn Mogul	280	6,000
	3	dsl	425	Wisn Mogul	280	6,000
Glendale Drlg Co	1	gas-gaso-btne	320	M-CSCO U-10	330	5,000
Harper-Turner Drlg Co	5	gas	320	Emsco G-300	—	6,000
O'Rourke-McGirl Drlg Corp	1	gas-btne	—	M-CSCO U-10	450	6,000
Pontotoc County						
J G Cantrell Drlg Co	1	gaso	185	Emsco T-160	165	4,000
	2	gas	100	Wisn	100	2,000
Don Clawson	1	gas-btne	240	Brwstr N-4	185	3,500
Pottawatomie County						
Barrett Petroleum Co	3	dsl	—	Wisn Gnt	300	5,500
	5	gas-gaso	—	Brwstr N-7	750	8,500
Kaybert Drlg Co	1	gas	225	Beth Breeze	245	5,000
Reed Drlg Co Inc	2	gas-gaso	—	Crdwll D	410	5,500
Seminole County						
An-Son Drlg Co	3	gas	400	Beth Breeze	250	4,500
Austin-Dunham Inc	1	gas-btne	350	M-CSCO U-34	300	6,000
Austin Drlg Co	1	dsl	300	M-CSCO U-34	300	5,500
R L Horn & Sons Drlg Co	1	dsl	185	Frnks Comet	300	5,500
Johnson-Bates Drlg Co	1	gas	245	M-CSCO U-34	300	4,500
Melco Drlg Co	1	btne	265	Brwstr N-35	185	5,000
	2	btne	265	Brwstr N-35	185	5,000
Perkins-Houston Drlg Co	2	gas	225	M-CSCO U-34	180	4,500
Poteet Wysor & Eckles Inc	1	gas-btne	225	M-CSCO U-34	185	5,000
Seran & Howard Drlg Co	1	gas	225	Beth	200	5,000
Troup & Suttles Inc	2	gas-gaso	200	Wilson	370	5,000
Wade Drlg Co Inc	3	dsl	325	Crdwll L	225	4,500
Stephens County						
Bryant-Hayward Drlg Co	4	gas	900	Brwstr N-75	900	12,000
Goldsmith Drlg Co	2	—	400	Natl 50	—	8,000
Holliman Drlg Co	1	gas	500	M-CSCO U-15	900	7,500
	2	gas	350	M-CSCO U-15	550	7,500
	3	gas	255	M-CSCO U-15	600	7,500
Tom Jack Drlg Co	2	gas	200	Crdwll S-350	200	5,000
Nichols Drlg Co	1	gas-btne	450	Wisn Gnt	450	5,500
	4	gas-btne	450	Wisn Gnt	450	7,500
	5	gas-btne	1725	Natl 75-CA	1725	12,500
	6	gas-btne	1050	Wisn Titan	1050	15,000
Parker Drlg Co	60	gas-elec	—	Natl 34x10	2000	25,000
Perkins Bros Drlg Co	3	gas-btne	400	Beth S-60	370	7,500
Pierco Drlg Co	1	gas-LPG	400	Wisn Mogul	165	4,200
Viersen & Cochran	11	gas	1525	Natl 110	1530	18,500
Dick Wegener Drlg Contr	3	gas	350	Whind B-85	500	10,000
Texas County						
Garvey Drlg Co	18	dsl	300	Wisn Roadair	450	6,000
Graham-Michaelis Drlg Co	1	dsl	275	Beth Twister	500	6,500
	10	dsl	600	M-CSCO U-15	600	9,000
Moran Bros Inc	2	gas	700	Emsco GA-500	750	9,500
R W Rine Drlg Co	3	gas-btne	520	M-CSCO U-15	600	7,500
Schafer Drlg Co	9	gas-gaso	300	Ideco H-35	300	7,500
Earl F Wakefield	4	gas-btne	750	Wisn Gnt Rdair	750	9,500
Tommy Ward Drlg Co	1	gas-btne	300	M-CSCO U-35	426	7,000
	2	gas	300	Brwstr N-45	600	7,500
	3	gas	350	Brwstr N-35	650	5,000
Webster Drlg Co	7	gas-btne	700	M-CSCO U-15	700	8,500
Wagoner County						
R W I T Drlg Co	1	gas-LPG	150	Crdwll	150	3,000/3½"
Woods County						
Bryant-Hayward Drlg Co	1	gas	675	Natl 50	675	8,500
Summit Drlg Corp	1	dsl	—	Emsco 450	480	7,000
Woodward						
Nichols Drlg Co	8	gas-btne	700	Natl 50-A	700	9,000
OREGON						
Crook County						
Miracle & Wooster Drlg Co	—	gas	850	"Oilwell" 76	700	10,000
PENNSYLVANIA						
Berks County						
C S Garber & Sons Inc	—	gas-gaso	—	—	32	1,500
	—	gas-gaso	—	—	32	1,500
	23	dsl	—	Reich	—	1,200
Clearfield County						
Delta Drlg Co	30	dsl	670	Emsco G-500	500	8,500
Fairman Drlg Co	1	gas-btne	500	Beth M-58	600	10,000
S W Jack Drlg Co	3	gas	650	M-CSCO U-15	650	8,500
Elk County						
Delta Drlg Co	24	dsl	670	Emsco GC-500	500	8,500
Indiana County						
Delta Drlg Co	34	gas-btne	800	M-CSCO U-15	600	8,000
Fairman Drlg Co	3	gas-btne	500	Wisn Gnt	600	9,000
S W Jack Drlg Co	1	gas	635	M-CSCO U-15	635	8,500
Lehigh County						
C S Garber & Sons Inc	26	dsl	—	Ingersoll	135	130
	27	dsl	—	Ingersoll 4	—	250

Tool Pusher, Alvin (Red) Knowles, for George W. Graham Drilling Company, drilled the wells described here.

"How Two Wells in Iberville Parish Converted Us to the Dorrco D-Sander"

"You don't often get to drill two wells —side-by-side and 100 feet apart— with the same rig, pusher and crew. Yet that is just what happened in this instance. We found that the Dorrco D-Sander saved us 2½ days and two bits. In addition, many other savings were realized.

"Here's what happened:

"On the first hole, the Size 4 D-Sander was not used until 8916 feet. Trouble had already started so the hole was lost. The rig was then skidded 100 feet and a second well was spudded. The D-Sander was used on this well from the surface to 8860 feet.

"Results?—The well was completed successfully without trouble. In addition, we saved 2½ days drilling time, two bits, and a substantial number of fluid end parts."

This contractor—The George W. Graham Drilling Company—was so impressed that they ordered a Size 6 D-Sander for another rig.

Results such as this dramatize the high efficiency of every Dorrco D-Sander. You can expect virtually complete sand removal and reliable operation whenever you use one.

Dorrco D-Sanders are made in three basic sizes—two, four, and six. They are also made in two basic types—the "Regular" D-Sander removes all particles less than 60 microns while the "Flour Sand" units remove anything above 30 microns in size. Regardless of where you drill, there is a Dorrco D-Sander especially for you. Write for full information!

SWACO

SALT WATER CONTROL Inc.

A Sid Richardson Development Company

1211 Ft. Worth National Bank—Phone: ED 2-4434—Ft. Worth, Texas

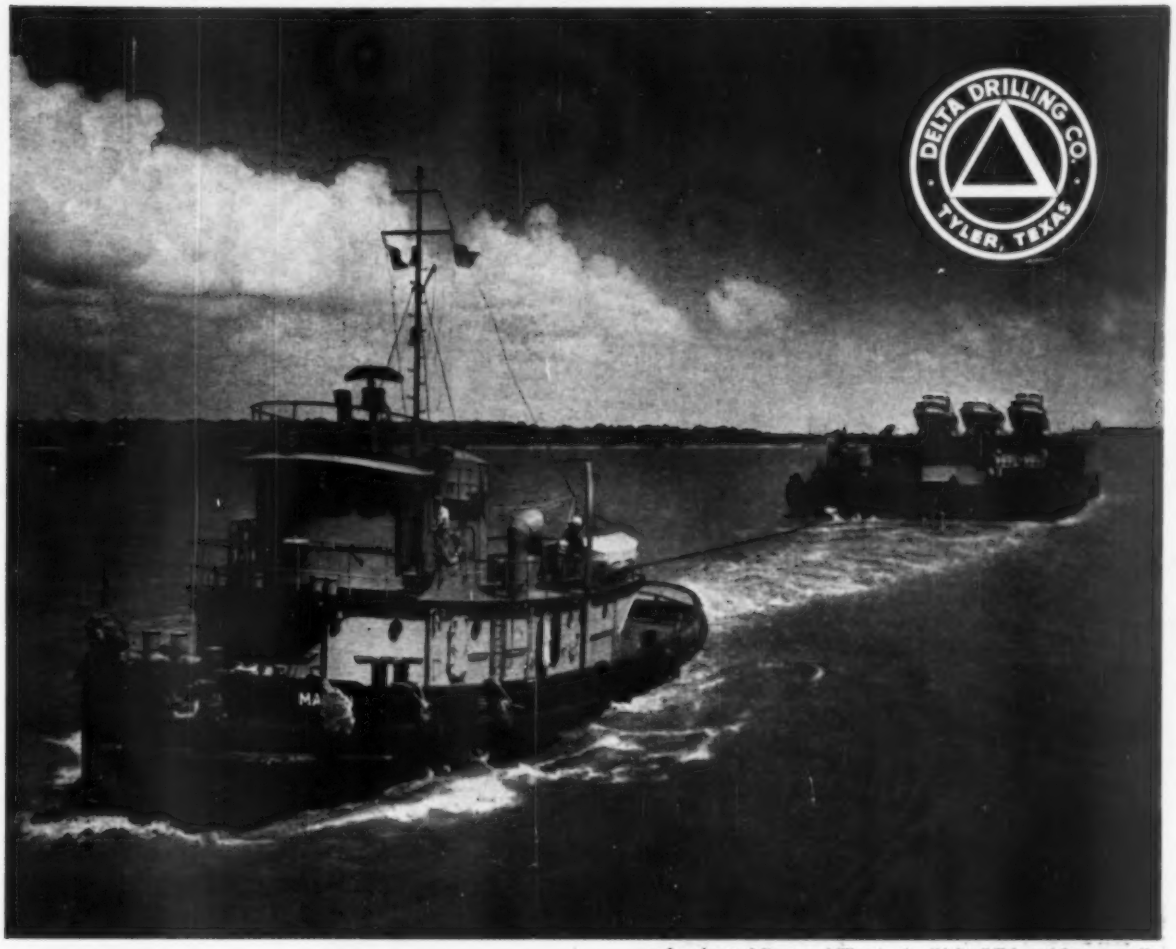
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Montgomery County						
C S Garber & Sons Inc	—	gas-gaso	—	—	32	2,000
	24	dsl	—	Ingersoll	135	130
	25	dsl	—	Ingersoll	135	400
Somerset County						
Delta Drlg Co	33	gas-btne	624	Natl 50-A	450	7,000
Westmoreland County						
Delta Drlg Co	10	dsl	560	M-CSCO U-15	560	7,000
Fairman Drlg Co	2	gas-btne	500	"Oilwell" 66	600	9,000
SOUTH DAKOTA						
Branyan Drlg Co	1	dsl	600	Frnks 6000	600	6,000
Harding County						
Signal Drlg & Expl Inc	1	gas-btne	800	M-CSCO U-40	800	10,000
TEXAS						
Anderson County						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wisn Giant	300	5,500
B G Byars Power Drlg Co	2	gas-btne	1145	Emsco GA-500	750	10,500
Calco Drlg Co	5	dsl	325	Beth S-45-E	300	5,500
M J Delaney Co	29	gas-btne	500	Beth 450	750	11,000
Halbert Drlg Co	1	gas-btne	255	Wisn Torcair	285	5,500
Maxwell Herring Drlg Corp	1	gas	300	Wisn Mogul	400	6,000
W B Hinton	3	dsl	—	M-CSCO	—	1,200
Dale Mount Drlg Inc	109	stm	—	Emsco	—	14,000
Trant Drlg Co	1	dsl	—	M-CSCO U-15	—	9,000
Andrews County						
Arrow Drlg Co	24	dsl	1200	Emsco 1000	—	14,000
Bayar-Hunefelt Drlg Co	2	gas-btne	350	Brwstr N-45	550	7,500/4"
Forest Blackstock Inc	1	gas	450	Emsco GB-350	450	8,000
	4	gas	570	Emsco GB-350	570	8,000
Brantly Drlg Co Inc	5	gas	375	Emsco 250	250	4,000
Cactus Drlg Corp of Tex	9	gas-btne	800	Brwstr N-75	—	12,500
M J Delaney Co	27	gas-btne	500	Beth 450	850	11,000
Denver Drlg Corp	1	gas	370	Crdwll EC	370	5,000
Empire Drlg Co	9	dsl	325	Wisn Giant	550	7,500
Lloyd R French Co	3	gas-btne	650	Natl 50	600	7,500
	4	gas-btne	1200	Natl 75	900	12,500
Fryer & Hanson Drlg Co	4	gas-btne	1150	"Oilwell" 76	1200	12,000
Great Western Drlg Co	17	gas-gaso	765	M-CSCO U-914B	1260	15,000
	27	gas-gaso	853	M-CSCO U-914A	1125	15,000
O E Hall Drlg Co	3	gas	320	M-CSCO U-15	700	8,000
Helmerich & Payne Inc	39	gas	1100	"Oilwell" 96	1300	14,000
	41	gas	1200	Natl 110	1500	15,000
Hewgley Drlg Co	6	gas-btne	—	Emsco GB-500	650	9,000
Hissom Drlg Co	1	gas	600	Emsco 500	600	8,500
Johnson-Gadbois Drlg Co	2	gas	230	Natl T-20	—	5,500
Carl B King Drlg of Tex	1	gas-gaso	1000	Natl 100	1000	13,500
La Mance Drlg Co	3	btne	550	"Oilwell" 64	—	6,500
Llano Drlg Co	3	gas	—	"Oilwell" 96	975	14,000
Lowe Drlg Co	6	gas	500	M-CSCO U-15	500	7,500
Milhoan Drlg Co	3	gas	900	Beth 450	—	10,000
Parker Drlg Co	4	gas	—	Natl 100	1400	14,000
	28	gas	—	Natl 50	700	9,000
	41	gas	—	Natl 100	1400	14,000
	47	gas	—	Natl 100	1400	14,000
	54	gas	—	Natl 125	1400	20,000
Sharp Drlg Co	20	gas	1350	Beth MC-950	1350	15,000
	35	gas	1500	Beth M-810	1500	18,000
	36	gas	1350	Beth MC-950	1350	15,000
	40	gas	1350	Beth Tornado	1350	14,000
A W Thompson Inc	6	gas	600	Beth 450	1050	11,000
Tri-Service Drlg Co	5	gas	825	"Oilwell" 76	825	10,000
Warton Drlg Co	3	gas	970	Natl 100	1600	14,000
Western Drlg Co Inc	14	dsl	375	Emsco 500	375	8,000
	15	dsl	375	Emsco 500	375	8,000
Western Serv Drlg Co Inc	1	gas-btne	340	Natl 50	360	5,000
Carl J Westlund Inc	5	gas-btne	650	Natl 50	—	8,500
Aransas County						
Camden Drlg Co	Bge 2	dsl	600	Natl T-32	300	7,500
C G Glasscock Drlg Co	3	dsl	1500	Emsco J-1250	—	17,000
	10	dsl	750	Natl 50	—	9,000
Archer County						
Harvey Drlg Co	3	gas-btne	350	Wisn Mogul	400	5,000
Armstrong County						
Drlg & Expl Co of Del Inc	25	gas	225	Frnks 137/33 DTDX	400	5,000
Atascosa County						
Allen & Morris	7	dsl	500	Natl 75	900	10,000/5"
Bay City Drlg Co Inc	1	gas-btne	430	"Oilwell" 52-T	430	7,000
Buzzini Drlg Co	7	gas-btne	1920	Wisn Atlas	1210	13,000
	8	gas-btne	1920	Wisn Titan	1210	13,000
Pegg Bros Drlg Co	2	gas-btne	110	—	110	3,000/3½"

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Baylor County						
A D McDuffie	1	btne	165	Big Four	145	2,500
Bee County						
Allen & Morris	3	stm	500	Emsco H-46M	1200	11,000/5"
Buzzini Drlg Co	5	gas-btne	1920	Wisn Gnt	1210	13,000
Field Drlg Co	3	dsl	1110	Emsco 500	520	10,000
Fitzpatrick Drlg Co	3	dsl	775	Brwstr N-7	700	8,500
C G Glasscock Drlg Co	7	gas	800	M-CSCO U-15	—	9,000
Rhodes & Hicks Drlg Corp	1	gas-btne	370	Frnks 137	200	5,500
Viking Drlg Co	4	gas-gaso	730	M-CSCO U-10	500	5,500
Bexar County						
Walters Drlg Co Inc	11	gas	150	Mayhew 1000	150	600/2⅛"
Borden County						
Choya Drlg Co	1	gas	750	Emsco GB-500	780	9,500
Clark Dale Drlg Co Inc	3	gas	—	"Oilwell" 66	660	10,000
Empire Drlg Co	2	gas	500	Brwstr N-7	750	9,500
Frank Frawley Drlg Co	4	gas	—	M-CSCO U-40	850	10,000
John Grappe Drlg Co	3	gas-btne	1000	L C Moore	900	13,000
O E Hall Drlg Co	2	gas	320	M-CSCO U-15	700	8,000
Johnn Drlg Co	8	gas	500	Brwstr N-75	700	10,000
Kerr-McGee Oil Ind Inc	3	gas	800	Natl 75	832	11,500
Layton & Newell Drlg Co	2	gas-btne	450	Natl 75	780	12,000
	3	gas-btne	500	Natl 75	820	12,000
Chas E Long Jr Inc	2	dsl	250	Emsco GA-500	520	10,000/3½
Rheay & Reynolds Drlg Co	3	gas	400	M-CSCO U-15	1200	6,500
	4	gas	350	Natl 50	1200	7,000
Triad Drlg Co	5	gas-btne	650	Beth 450	650	12,000
Urice Drlg Co	3	gas-btne	700	Emsco GB-500	700	9,000
Brazoria County						
C J Foster Drlg Co Inc	2	gas-LPG	—	Brwstr N-75	834	11,000
	3A	stm	—	Emsco EB-54-4	1000+	18,000
	4	gas-LPG	—	Prtble CT-5	550	8,500
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	5,000
	12	stm	500	Natl 23-9-FED	1000+	20,000
Penrod Drlg Co	8	gas-btne	—	—	1230	10,000
Brazos County						
Maxwell Herring Drlg Corp	8	gas	300	Wisn Mogul	250	4,500
Brooks County						
Frio Drlg Inc	2	dsl	400	M-CSCO U-15	400	6,500
Stice Drlg Co	1	btne-gas	496	M-CSCO U-15	—	7,500
Brown County						
Irish Drlg Co Inc	2	btne	280	Wichtex R-3	—	3,000
Joe W Miller	2	btne	165	Wisn Spr	85	3,000/3½
Calhoun County						
Allen & Morris	5	pwr	1100	"Oilwell" 76	780	12,000
Dan L Clark Drlg Co	5	gas-btne	1025	Brwstr N-7	800	8,500
Falco Drlg Co	1	gas	750	Brwstr N-45	400	6,500
Neal Drlg Co	1	gas	750	Emsco G-500	560	9,500
Callahan County						
Low Drlg Co	2	btne	—	Wilson	145	3,000
	3	btne	—	Wilson	165	2,500
Rhodes Drlg Co	1	gas	300	Wisn Giant	450	5,500
Woodson Prod Co	2	gas	600	M-CSCO U-15	900	8,500
Cameron County						
Turnbull & Zoch Drlg Co	3	gas-btne	1125	Wisn Titan	1125	16,000
Carson County						
Latexo Drlg Co Inc	2	gas-btne	370	M-CSCO U-34	370	6,500
Schafer Drlg Co	6	gas-gaso	200	M-CSCO U-34	200	5,000
Cass County						
Glenn Drlg Co	2	dsl	280	M-CSCO U-15	450	8,500
Chambers County						
Bass Drlg Co	3	gas-gaso-btne	225	M-CSCO U-34	—	6,500
Brewster-Bartle Drlg Co Inc	3	dsl	—	"Oilwell" 96	1500	16,000
	4	gas	—	"Oilwell" 76	—	11,000
	10	dsl	—	"Oilwell" 76	—	11,000
Clegg & Hunt	2	stm	—	Emsco H-54	—	11,000
Continental Drlg Co	7	dsl	1200	Emsco GB-800	1200	14,000
Continental Marine Expl Co	5	gas-btne	1480	Wisn Titan	700	12,000
Meredith & Co	1	gas-gaso-btne	—	Emsco G-500	680	9,500
Howard Parker Co	6	gas-btne	400	Crdwll D	500	8,000
Carnes W Weaver Drlg Co	5	gas-btne	465	M-CSCO U-34	—	5,000
Cherokee County						
LeCuno Oil Corp	4	gas-LPG	1050	Wisn Titan	1050	13,500
Trant Drlg Co	2	dsl	—	Ideco	—	12,000
Travis Ward Drlg Co	2	dsl	1550	Wisn Titan	1100	12,500
Clay County						
Clyde Gibson Drlg Co	1	gas	600	Wisn Gnt Rdair	700	7,000
Jack Grace Drlg Co	19	gas-btne	255	Wisn Giant	350	5,000
H O Grace Drlg Co	1	btne	—	—	—	6,000
Lin-Mour Drlg Co	1	gas	315	Wisn Mogul	400	4,600
W B Omohundro	4	btne	450	Wisn Atlas	—	6,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Cochran County						
Hissom Drlg Co	3	gas	450	Beth S-60	450	6,500
Sojourner Drlg Corp	1	btne	218	M-CSCO U-15	—	7,500
Western Drlg Co Inc	13	dsl	600	Crdwll O	325	9,000
	17	btne	440	Crdwll L	145	4,000
Coke County						
Empire Drlg Co	3	gas	500	Brwstr N-75	975	11,000
Roy Guffey Drlg Co	2	gas-btne	520	M-CSCO U-15	520	7,500
Coleman County						
Burger Drlg Co	1	gas	325	Wisn Mogul	185	4,000
Maxwell Drlg Co	1	btne-gas	220	Brwstr N-4	220	5,500/3½"
Haynes B Ownby Drlg Co	1	gas-btne	—	M-CSCO U-900	—	9,500
Collin County						
Luke Grace Drlg Co	6	dsl-gas	300	Wisn SE Gnt	300	6,500
Travis Ward Drlg Co	3	gas-LPG	2000	Wisn Spr Titan	1400	16,000
Colorado County						
Appell Petroleum Corp	3	gas-gaso	510	Brwstr N-4	225	5,500
Bilbo-Redding Drlg Co Inc	3	stm	1050	Emsco UBLS 54	1000+	12,500
Columbia Drlg Co	2	gas	600	Natl 75	—	11,500
Holmes Drlg Co	2	stm	—	Emsco ECA	1000+	15,000
Comanche County						
Walters Drlg Co Inc	8	gas	220	Mayhew 1000	220	600/2⅛"
Cooke County						
Brown & Martin Drlg Co	1	btne	230	Wisn Giant	215	5,500
	2	btne	150	Wilson	105	1,500
Roy Guffey Drlg Co	3	gas-btne	430	M-CSCO U-34	260	5,500
Gene McCutchin	5	gas	275	Wisn Giant	275	6,500
E W Moran Drlg Co	3	dsl	285	Wisn Giant	650	7,500
Russell & Russell Drlg & Prod Co	1	gas-gaso-btne	275	Wisn Giant	180	4,500
	3	—	350	Wisn Mogul Trcair	350	5,000
Trachta Drlg Co	1	dsl	250	Wilson	185	3,000
Crane County						
Bickerstaff & Tibbets Drlg Co	4	gas	675	M-CSCO U-15	675	9,000
Forest Blackstock Inc	3	gas	650	Emsco 500	650	9,000
Brantly Drlg Co Inc	1	gas	365	Emsco 500	500	9,000
	2	gas	975	Emsco 800	1000	14,000
Choya Drlg Co Inc	5	gas-btne	700	Emsco GB-350	660	8,500
Dixilyn Drlg Corp	4	gas	950	Natl 80	950	14,000
Frontier Drlg & Prod Co	6	gas-LPG	700	Natl 50	700	8,000
Gardner Bros Drlg Co Inc	6	gas-btne	500	Natl 75	700	10,500
	11	gas-btne	750	Natl 100	1050	12,500
	20	gas-btne	275	Natl T-25	350	4,000
Guadalupe Drlg Co	1	gas-btne	700	Ideco M 1000	—	10,000
Helmerich & Payne Inc	42	gas	970	Natl 100	1000	13,000
Hewgley Drlg Co	5	dsl	—	Emsco J-750	975	11,000
Johnn Drlg Co	7	gas	185	Brwstr N-4	300	5,500
Laughlin-Porter Drlg Co Inc	4	gas	1650	Ideco 1350	—	14,000
	7	gas	400	Wisn Torcair	—	5,000
Layton & Newell Drlg Co	1	gas-btne	500	M-CSCO U-15	600	8,000
Lee Drlg Co	1	gas-gaso	700	Natl 50	—	8,000
	2	gas-gaso	700	Natl 50	—	8,000
	7	gas-gaso	440	Beth S-55	—	6,000
McDaniel & Beecherl Drlg Co	10	gas-gaso	—	"Oilwell" 66	—	10,000
Parker Drlg Co	59	gas	—	Natl 75	1000	11,000
Pico Drlg Co	3	gas-btne	610	M-CSCO U-15	470	8,500
Rowan Drlg Co Inc	22	gas-btne	600	Natl 50	766	7,000
B B Smith Inc	1	gas	600	Brwstr N-4	300	6,000/3½"
	2	gas	600	M-CSCO U-15	450	7,000
	3	gas	400	Beth S-45	200	6,000/3½"
Tibbits Drlg Co	5	gas	350	Wisn Gnt	560	7,500
Triad Drlg Co	1	gas-btne	500	Natl 50	500	7,000
Crockett County						
Clark Dale Drlg Co Inc	2	gas	—	Natl 50	600	8,500
Texita Oil Co	1	dsl	320	Emsco GA-250	300	6,500
	1	dsl	320	Emsco GA-250	300	6,500
Crosby County						
Smith & Breyer	4	gas	530	Frnks	530	9,500
Culberson County						
Bickerstaff & Tibbets Drlg Co	5	dsl	300	Frnks SAL-5000	320	5,000
McQueen & Stout Drlg Co	9	LPG	225	Crdwll RL	185	4,500
Pico Drlg Co	4	gas-btne	150	Wisn Mogul	325	4,000
Dallam County						
Latexo Drlg Co Inc	1	gas-btne	370	Beth S-55 Twstr	370	7,500
Dawson County						
B B M Drlg Co	5	gas-btne	600	Emsco J-750	800	12,800
Cactus Drlg Corp of Tex	10	gas-btne	700	Beth M-58	700	9,000
Coroco Drlg Co	6	gas-gaso	400	"Oilwell" 66	500	9,000
Frank Frawley Drlg Co	3	gas	—	Natl 100	1050	13,000
Keating Drlg Co	8	gas-gaso	—	—	650	8,500
Milhoan Drlg Co	7	gas	600	"Oilwell" 76	—	8,000
Dale Mount Drlg Inc	101	gas	850	Emsco	570	9,000
	115	gas	1200	Emsco	1200	12,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Deaf Smith County						
Edgar Davis Drlg Co	12	gas-btne	650	Wisn Giant	675	10,000
Jack Grace Drlg Co	16	gas-btne	1020	Wisn Titan	1200	12,500
La Mance Drlg Co	4	btne	1050	Wisn Titan	—	13,000
De Witt County						
Allen & Morris	4	gas	400	Natl 50	400	8,500/5"
Dan L Clark Drlg Co	2	gas-btne	1000	Emsco GC-500	500	7,500
Harkins & Co	1	gas-gaso	555	M-CSCO U-15	555	9,500
	3	gas-gaso	850	M-CSCO U-15	850	10,000
	4	gas-gaso	700	Wisn Giant	700	9,500
Dimmit County						
Sutton Drlg Co	1	dsl	—	—	225	3,500
	4	dsl	350	Brwstr N-4	875	6,500
	6	dsl	121	Alamo	225	5,000/2½"
Donley County						
Edgar Davis Drlg Co	11	gas-btne	325	M-CSCO U-15	600	7,500
Duval County						
Flournoy Drlg Co	1	gas-btne	225	Ideco HD-35	320	5,000
General Well Drlg Inc	8	btne	400	—	185	4,500/3½"
Gilmour Drlg Co	1	gas	800	M-CSCO U-15	600	8,500
Eastland County						
Irish Drlg Co Inc	3	btne	285	Wisn Mogul	—	4,000
Ector County						
Bickerstaff & Tibbets Drlg Co	6	gas	675	M-CSCO U-15	675	10,000
Big West Drlg Co	17	gas-btne	600	Wisn Titan	900	13,000
Brantly Drlg Co Inc	4	gas	375	Beth S-55	480	6,500
	6	gas	400	Natl 50	750	9,000
Cactus Drlg Corp of Tex	2	gas-btne	300	Brwstr N-4	460	5,000
	6	gas-btne	300	M-CSCO U-15	—	8,500
Calco Drlg Co	3	gas-btne	275	Emsco GB-250T	250	5,500
Choya Drlg Co Inc	3	gas-btne	900	Beth MC-650	900	12,000
Coroco Drlg Co	1	gas-gaso	500	Beth 650	650	12,500
	4	gas-gaso	650	Wisn Spr Titan	900	15,000
M J Delaney Co	26	stm	—	Natl T-38	—	15,000
	30	gas-btne	500	Beth 1013	1200	15,000
Donnell Drlg Co	5	gas-btne	650	M-CSCO U-15	650	8,000
	6	gas-btne	975	Beth MC-450	975	10,000
	9	gas-btne	1400	Beth MC-950	1400	15,000
	10	gas-btne	650	Beth M-58	650	10,000
	12	btne	400	Beth S-45-E	—	5,000
Eastland Drlg Co	1	gas	—	—	750	10,000
	2	gas	—	—	540	7,500
	4	gas	—	—	190	4,500
Empire Drlg Co	7	gas	600	Wisn Titan	975	13,500
Lloyd R French Co	1	gas-btne	765	Natl 50	600	9,000
	2	gas-btne	675	M-CSCO U-15	600	7,500
Gardner Bros Drlg Co Inc	5	gas-btne	500	Natl 75	675	9,000
	8	gas-btne	500	Natl 50	675	7,000
	10	gas-btne	750	Natl 100	1050	12,500
	15	gas-btne	1000	"Oilwell" 96	1500	16,000
	16	gas-btne	1000	Natl 125	1400	15,000
	18	gas-btne	400	Natl 50	575	7,000
Highland Drlg Co	1	gas	—	Natl 50	550	8,200
Carl B King Drlg Co of Tex	5	gas-gaso	1000	Natl 100	1000	13,500
King-Phillips Inc	1	gas-gaso	695	Natl 50	—	7,500
La Mance Drlg Co	5	btne	550	M-CSCO U-15	550	7,500
Lee Drlg Co	5	gas-gaso	1050	Natl 100	—	13,000
	6	gas-gaso	1050	"Oilwell" 76	—	13,000
Llano Drlg Co	4	gas	—	Natl 75	1050	12,000
Lowe Drlg Co	3	gas	1000	Natl 100	1000	12,500
McQueen & Stout Drlg Co	12	LPG	225	Crdwll RL	185	4,500
Milestone Drlg Co	100	dsl	550	Ideco H-525	600	7,500
Parker Drlg Co	32	gas	—	Natl 50	700	9,000
	58	gas	—	Natl 100	1400	14,000
Robinson Bros Drlg Co	3	gas	300	Brwstr N-55	500	6,500
Rowan Drlg Co Inc	16	gas-btne	504	Natl 50	660	7,000
Ray Smith Drlg Co						
Nancy Ann II		gas-LPG	225	Ideco H-25	160	4,500/3½"
Sophie Jean		gas-LPG	625	Natl 50	625	8,000
A W Thompson Inc	1	gas	1500	Emsco A-1500	1800	18,000
C D Turner Drlg Co	1	dsl	—	Brwstr N-4	—	5,500
Warton Drlg Co	2	gas	600	Natl 50	700	8,500
Fayette County						
Hamman Oil & Ref Co	6	dsl	250	Brwstr N-4	310	6,500
Fisher County						
Drillers Inc	U-15	dsl	—	M-CSCO U-15	600	7,200
General Geophysical Co	32	btne	—	—	500	7,500
Paine Drlg Co	5	btne	450	Wisn Giant	450	7,000
A B See Drlg Co	2	gas	400	Wisn Mogul Torcair	250	5,000
West Central Drlg Co	7	gaso-btne	225	Wisn Giant	250	5,000
Foard County						
E W Moran Drlg Co	2	gas	500	Wisn Giant	650	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Fort Bend County						
Columbia Drlg Co	5	dsl	400	M-CSCO U-15	—	8,500
C J Foster Drlg Co Inc	6	gas-LPG	—	Frnks H-37	260	6,000
Texdrill Corp	1	gas-btne	226	Brwstr N-4	300	6,500/4"
Franklin County						
Maxwell Herring Drlg Corp	4	gas	600	Wlsn Gnt Rdair	600	8,000
Freestone County						
Ace Drlg Co	3	gas	750	Natl 50-A	450	7,500
Bay City Drlg Co Inc	3	gas-btne	560	"Oilwell" 66	560	10,800
B G Byars Power Drlg Co	3	dsl	400	Emsco G-300	300	5,500
M J Delaney Co	31	gas-btne	450	Wlsn Gnt Rdr	650	7,000
Gibson Drlg Co	4	gas-btne	226	Wlsn Mogul	225	4,500
Frio County						
Pegg Bros Drlg Co	1	gas-btne	145	Brwstr	145	4,500/3½"
Gaines County						
Arrow Drlg Co	17	gas	1260	Emsco 1250	—	14,000
B B M Drlg Co	10	gas-btne	200	Emsco GA-500	450	7,000/3½"
Blount Drlg Corp	2	gas-btne	675	M-CSCO U-15	675	8,000
M J Delaney Co	19	gas-btne	600	Emsco J-1250	1200	15,000
Great Western Drlg Co	35	dsl	300	M-CSCO U-15	760	7,500
Johnn Drlg Co	3	gas	650	Wlsn Atlas	900	10,000
Keating Drlg Co	11	gas-gaso	—	—	650	8,500
Kerr-McGee Oil Ind Inc	34	dsl	300	Frnks LTX-5000	300	5,000
Chas E Long Jr Inc	3	dsl	400	Emsco GA-500	520	10,000/3½"
Lowe Drlg Co	5	gas	750	Natl 75	750	10,000
Marcum Drlg Co	5	gas-btne	1000	Brwstr N-95	1525	14,000
Moran Oil Frod & Drlg Corp	1	gas	—	M-CSCO U-15	800	8,500
Dale Mount Drlg Inc	112	gas	1200	Emsco	1200	12,000
Robinson Bros Drlg Co	1	gas	800	Brwstr N-75	800	10,000
Texas R F O Inc	4	gas	675	M-CSCO U-15	675	8,500
Triad Drlg Co	4	gas-btne	400	M-CSCO U-34	400	6,500
Galveston County						
Bilbo-Redding Drlg Co Inc	Bge 7	dsl	550	"Oilwell" 64-B	—	7,500
Continental Marine Expl Co	Bge 12	dsl	2000	Wlsn Titan 66	1875	22,800
C G Glasscock Drlg Co	8	dsl	1200	Natl 75	—	12,000
Grey Wolf Drlg Co	4	gas-btne	585	Emsco GB-500	—	9,500
Howard Parker Co	1	gas-btne	600	Crdwll D	500	8,000
Penrod Drlg Co	18	stm	—	—	—	15,000
The Power Rig Drlg Co	Bge 7	dsl	1200	Emsco GB-800	—	15,000
Garza County						
Hewgley Drlg Co	1	gas-btne	—	Emsco GA-500	650	8,500
	4	gas-btne	—	Emsco GA-500	650	8,500
Pico Drlg Co	1	dsl	368	Brwstr N-4	216	5,000
St John Drlg Co	1	gas	400	Wlsn Gnt Rd	700	8,500
Smith & Breyer	2	gaso	—	Cooper	—	3,000
	3	btne-dsl	355	Spencer	355	4,250
Texas R F O Inc	3	dsl-gas	250	Emsco GA-250	290	5,000
Western Drlg Co Inc	6	dsl	600	—	290	6,000
Glasscock County						
Ormand Bros Drlg Co	2	gas	550	Wlsn Giant	550	7,000
Goliad County						
Boyd & Durst Drlg Contr	2	gas-btne	650	Wlsn Giant	700	8,500
Harkins & Co	7	dsl	600	M-CSCO U-15	600	9,500
Gonzales County						
Sutton Drlg Co	7	dsl	121	Alamo	225	5,000/2⅛"
Grayson County						
Jack Grace Drlg Co	8	gas-btne	625	Wlsn Atlas	1200	10,000
Tibbits Drlg Co	3	gas	350	Wlsn Giant	560	7,500
Gregg County						
Delta Drlg Co	7	stm	750	Emsco UB-54	1200	12,000
United Drlg Co (Texas)	1	gas-btne	225	Beth S-45-E	240	5,000
Hansford County						
Arrow Drlg Co	10	gas	560	Emsco 500	—	8,000
Baker & Taylor Drlg Co	1	dsl	800	M-CSCO U-15	800	8,500
	4	gas-btne	750	Emsco G-500	750	9,500
	8	gas-btne	750	Emsco G-500	750	9,000
Cree Drlg Co Inc	4	gas-btne	350	Emsco GA-500	600	9,000
	9	gas-btne	350	M-CSCO U-15	650	8,500
Drlg & Expl Co of Del Inc	35	gas-gaso	1200	Emsco GB-800	900	12,000
Foree Drlg Co	2	gas-btne	300	M-CSCO U-15	600	7,500
Rowan Drlg Co Inc	10	gas-btne	1020	Beth 450	76	9,000
Rip C Underwood	1	gas-LPG	660	M-CSCO U-15	660	9,500
Wagner & Wyant Drlg Co Inc	2	dsl	500	M-CSCO U-15	675	8,000
Webster Drlg Co	3	gas-btne	750	Wlsn Atlas	750	10,000
Hardin County						
Bass Drlg Co	2	gas-gaso-btne	675	M-CSCO U-15	—	10,000
Owen Drlg Co	8	dsl	1040	Natl 50	1040	10,000
Carnes W Weaver Drlg Co	1	gas-btne	700	"Oilwell"	—	10,500
Harris County						
Bay City Drlg Co Inc	4	gas-btne	41	Brwstr N-45	420	8,000
Coastal Marine Drlg & Constr Co	2	dsl-btne	925	Ideco 800	600	9,000
Comet Drlg Co	3	stm	900	Ideco Jr Gnt	—	10,000
Continental Marine Expl Co	2	gas-btne	2120	Wlsn Titan	1340	14,500
Edwards & Bissett Inc	6	gas-btne	600	Ideco H-40D	500	7,000
C J Foster Drlg Co Inc	8	gas-LPG	—	"Oilwell" 64-A	366	8,000
Long Engineering Corp	1	stm	1200+	Natl 130	1200+	15,000
	2	gas-btne	1020	Emsco J-1000	1260	12,000
Mac Drlg Co	7	stm	500	Natl 34-26	5000	10,000
Miller Bros & Bowling	2	gas-btne	800	Emsco G-450	—	8,500
Haynes B Ownby Drlg Co	2	gas-btne	—	Wlsn	700	7,000
Pico Drlg Co	8	gas-btne	756	Beth M-58	925	10,500
Taylor Expl Co Inc	5	gaso	—	Mayhew	75	1,000
W P Taylor Drlg Co	2	gas	—	Natl	900	11,000
Texdrill Corp	2	gas-btne	292	M-CSCO U-15	560	9,500
W L B Drlg Co	1	gas-gaso-btne	350	Brwstr N-35	196	3,500
Harrison County						
Barnwell Drlg Co Inc	34	dsl	800	M-CSCO U-34	500	7,000
Jackson Oil Co	1	dsl	330	Crdwll O	520	6,500
LeCuno Oil Corp	1	gas-LPG	705	Wlsn Gnt Rdr	705	9,250
	5	dsl	250	Wlsn Mogul 42	250	6,500
Penrod Drlg Co	7	dsl	—	—	730	9,000
Tex-Mex Drlg Co	8	stm	—	—	1000+	9,000
Hemphill County						
Rowan Drlg Co Inc	2	gas-btne	840	Natl 75	1120	11,000
Henderson County						
Delta Drlg Co	22	gas-btne	530	M-CSCO U-15	600	8,000
Hidalgo County						
Falco Drlg Co	2	gas	600	Wlsn Gnt	650	8,000
Fitzpatrick Drlg Co	1	stm	800+	Ideco	1000+	12,000
	2	gas	950	M-CSCO U-40	900	10,000
General Well Drlg Inc	1	btne	250	—	185	5,500/3½"
	7	dsl	500	—	300	7,500
Gilmour Drlg Co	2	gas	800	Natl 50	600	8,500
Holmes Drlg Co	3	gas-gaso	—	Natl 110	1500	16,000
J & C Drlg Co	5	dsl	800	Wlsn 54	800	12,000
Hugh Kirkpatrick Inc	1	gas	696	TIW 5	712	8,000
	2	gas	1080	Natl 55-A	600	10,00
Viking Drlg Co	2	dsl	475	Natl 50-A	500	8,500
John W Voss Drlg Co Inc	1	pwr	625	Brwstr N-75	852	10,000
	2	pwr	500	Brwstr N-7	750	9,000
Well Drillers Inc	1	gas-gaso-btne	1140	Natl 75	870	9,500
Hockley County						
Drlg & Expl Co of Del Inc	14	gas-elec	1100	Natl 34-10	1000	17,000
Great Western Drlg Co	34	dsl	495	M-CSCO U-40	1200	10,000
	37	gas-gaso	700	M-CSCO U-40	1200	10,000
A W Thompson Inc	11	gas	650	Beth 450	1050	13,500
Hopkins County						
W B Hinton	2	dsl	—	M-CSCO U-15	350	12,000
Houston County						
Ace Drlg Co	4	gas	680	Emsco G-500	500	8,500
Howard County						
Bolin Oil Co & D H Bolin	7	gas	225	Beth S-50	185	4,500
Brantly Drlg Co Inc	3	gas	700	Brwstr N-75	750	11,000
	7	gas	975	Beth 450	1125	12,500
Frontier Drlg & Prod Co	7	dsl	300	Natl T-16	300	5,500
J E Jones Drlg Co	1	gas	500	"Oilwell" 66	630	8,000
Rowan Drlg Co Inc	9	gas-btne	900	Natl 75	1110	11,000
C D Turner Drlg Co	2	btne	180	Wlsn Mogul	180	4,500
Hutchinson County						
Cree Drlg Co Inc	2	gas-btne	255	M-CSCO U-10	360	4,500
	3	gas-btne	225	Wlsn Gnt	300	5,000
J R McGill	1	gas-gaso	—	Emsco	570	7,000
Schafer Drlg Co	7	gas-gaso	200	Ideco H-35	200	5,000
Irion County						
Tom Bomar Well Serv	4	gas-btne	175	Crdwll AL-63	150	2,500
Jack County						
B M Hester	1	btne	325	Natl T-20	200	6,000
Karper & Glass	2	gas	425	Beth C-50	425	6,000
	3	dsl	450	Beth S-55	450	7,000
	6	gas	276	Wilson	212	3,500
Ward Drlg Co	2	btne	300	Wlsn Gnt	600	5,000
Jackson County						
Al Buchanan Drlg Co	1	gas-gaso-LPG	1000	Ideco 10,000	561	9,000
Davis & Bates Inc	1	dsl	375	Brwstr N-4	350	7,000
Gilmour Drlg Co	3	gas	500	Wlsn Gnt	300	6,000
Henderson Drlg Corp	3	gas-btne	700	Natl 75	750	11,000
	4	gas-btne	1000	Natl B-80	1000	12,500
H H Howell Drlg Co	1	dsl	376	Frnks 5000	248	6,000
Jasper County						
Harry T Bryant Drlg Co Ltd	3	gas-btne	700	TIW 5	600	8,000
Timberland Expl Co	3	gas-btne	800	M-CSCO U-15	700	9,000
Jefferson County						
Clegg & Hunt	10	btne-gas	—	Natl 50-A	—	10,000
Henderson Drlg Corp	5	gas-btne	800	Natl 55	800	11,000
Holmes Drlg Co	1	gas-gaso	—	Beth ML-450	1000	11,000



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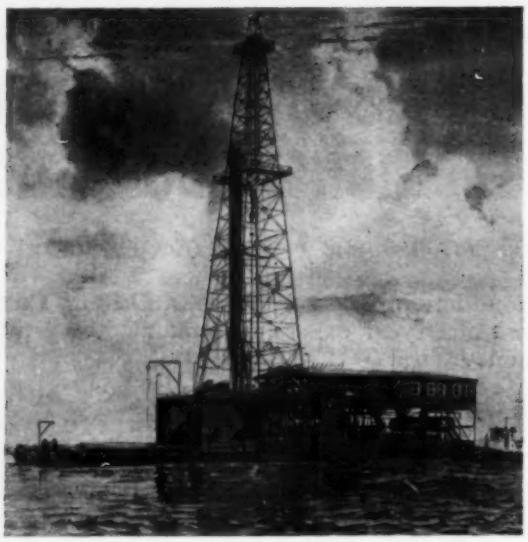
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Kilroy Drlg Co	3	gas	1000	Brwstr N-75	1000	12,000
Meredith & Co	3	gas-gaso-btne	—	"Oilwell" 96	1150	13,000
	4	gas-gaso-btne	—	Brwstr N-75	850	11,500
Jim Hogg County						
Flournoy Drlg Co	4	gas-btne	175	Franks	185	3,500
Well Drillers Inc	2	gas-gaso-btne	1821	Ideco 7-11 Spr	1446	14,000
Jim Wells County						
Harkins & Co	2	dsl	300	Wisn Giant	300	6,000
Rhodes & Hicks Drlg Corp	2	btne	370	Natl T-32	370	6,500
Texita Oil Co	3	dsl	260	Beth	300	5,000
Jones County						
Hack Drlg Co	2	btne	—	Crdwll S	161	4,500
	4	btne	—	—	161	2,500
Johnson-Gadbois Drlg Co	1	gas	440	Wisn Gnt	440	8,000
Sojourner Drlg Corp	2	dsl	320	M-CSCO U-15	—	5,000
	3	dsl	550	M-CSCO U-15	—	7,500
	4	btne	225	M-CSCO U-34	—	4,500
Woodson Prod Co	4	dsl	600	Mayhew 5000	270	5,500/4"
Karnes County						
Bilbo-Redding Drlg Co Inc	4	gas-LPG	1050	"Oilwell" 96	—	12,000
	8	gas-LPG	1600	Natl 110	—	13,500
Kirkwood & Morgan Inc	8	dsl	550	Brwstr N-4	550	7,000
Kenedy County						
Fitzpatrick Drlg Co	4	gas	1050	Beth Tornado	1000	13,000
C G Glasscock Drlg Co	4	dsl	1700	Natl 125	—	16,000
Kent County						
Empire Drlg Co	5	gas	325	M-CSCO U-15	550	8,000
West Central Drlg Co	5	gaso-btne	325	M-CSCO U-15	600	7,500
Kleberg County						
Bilbo-Redding Drlg Co Inc	Bge 6	dsl	1050	"Oilwell" 76	—	12,500
Conroe Drlg Co	1	stm	1000	Natl 34-10FE	1000	15,000
	3	gas-btne	675	M-CSCO U-15	675	9,500
Knox County						
Abb Drlg Co	1	gas	185	Wisn Super	145	2,500
	2	gas	200	Wisn Mogul	165	3,500
Ace Drlg Co	1	gas	680	Emsco G-500	500	8,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Anderson Drlg Co	1	btne	225	Wisn Mogul	—	4,000
Meredith Drlg Co	1	btne	225	Wisn Super	145	3,500
E W Moran Drlg Co	1	gas	500	M-CSCO U-15	560	7,500
Harold Shappell Drlg Co	1	btne	245	Wichtex	145	2,800
Tibbits Drlg Co	4	gas	350	Wisn Gnt	525	7,500
LaSalle County						
General Well Drlg Inc	3	btne	450	—	200	5,500/3½"
MIM Drlg Corp	1	dsl	500	Franks SA-4500	300	5,000
Sutton Drlg Co	3	dsl	300	Brwstr N-4	350	6,500
Lavaca County						
Harry T Bryant Drlg Co Ltd	2	gas-btne	700	—	600	8,000
Edwards & Bissett Inc	3	gas-btne	1100	Brwstr N-75	800	10,500
Holmes Drlg Co	6	gas-gaso	—	Beth MC-450	700	10,000
W P Taylor Drlg Co	3	gas	—	Natl	900	11,000
Leon County						
M J Delaney Co	24	gas-btne	500	Beth M-58	600	9,500
Liberty County						
Bass Drlg Co	1	gas-gaso-btne	675	M-CSCO U-15	—	10,000
Edwards & Bissett Inc	1	gas-btne	800	Wisn Gnt Rdair	800	8,500
Houston Oil Well Serv Co	2	dsl	—	Wisn Titan	1000	10,000
	5	stm	1000+	Natl	1000+	12,000
Howard Parker Co	2	gas-btne	500	Crdwll D	750	9,500
	5	gas-btne	600	M-CSCO U-15	900	10,500
Carnes W Weaver Drlg Co	6	gas-btne	540	Brwstr N-7	—	8,500
Limestone County						
Walters Drlg Co Inc	9	gaso	130	Mayhew 1000	130	800/2⅛"
	14	gas	—	Mayhew 1000	150	400/2⅛"
Lipscomb County						
Cree Drlg Co Inc	1	gas-btne	500	M-CSCO U-15	750	8,500
	5	gas-btne	825	M-CSCO U-40	975	14,000
Keating Drlg Co	15	gas-gaso	—	—	675	9,000
Webster Drlg Co	8	gas-btne	1050	Ideco 7-11	1050	12,000
Live Oak County						
Allen & Morris	2	stm	400	Alco BIW 11	600	12,000/5"
Field Drlg Co	1	dsl	1040	Natl 50-A	520	9,500
Turnbull & Zoch Drlg Co	2	stm	1600	Ideco	1000+	14,000
Viking Drlg Co	1	dsl	475	Natl 50	500	8,500

GULF COAST DRILLING SPECIALISTS

J. F. Burdett
President



F. E. Eischen
Special Representative

T. J. Fraley
Vice President

Wesley Gotreaux
Drilling
Superintendent

OPERATING SIX MODERN RIGS *to Meet Your Needs*
ON LAND AND WATER IN THE GULF COAST AREA

HARRY L. EDWARDS DRILLING COMPANY

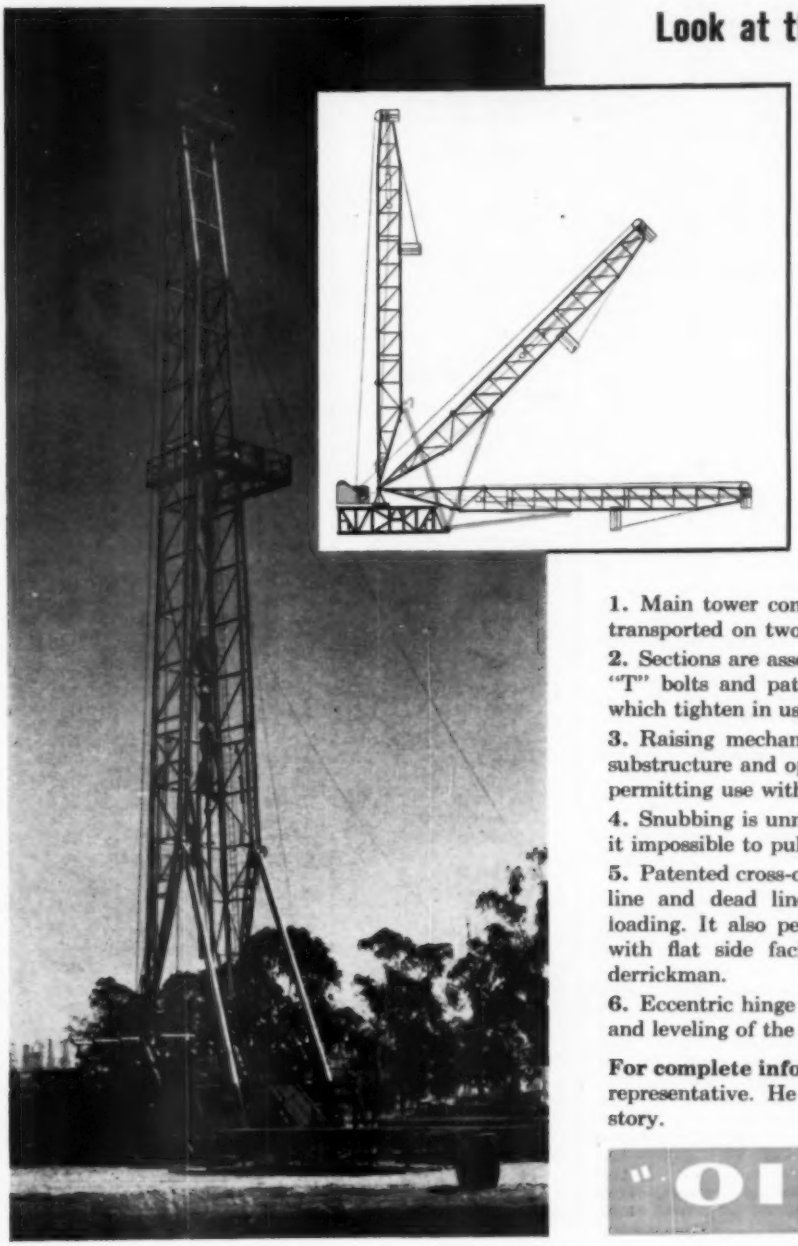
P. O. Box 6825 Phone GY 9-8000 Houston 5, Texas

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
Loving County						
Ellis	4	dsl	300	M-CSCO U-34	300	5,000
Leatherwood Drlg Co	2	gas	440	Natl T-32	—	7,000
McDaniel & Beecherl Drlg Co	6	gas-gaso	—	Hou Prtble	—	5,000
	11	gas-gaso	—	Hou Prtble	—	5,000
Fred Pool Drlg Co	3	gas	225	Wisn Gnt	250	5,500
Lubbock County						
Western Drlg Co Inc	9	btne	500	—	500	5,000
Lynn County						
Pico Drlg Co	1	dsl	427	Brwstr N-4	216	4,500/3½"
A W Thompson Inc	7	gas	650	Beth 450	1050	11,000
Tibbits Drlg Co	2	gas	350	Wisn Gnt	425	7,000
Marion County						
B F Edington Drlg Co Inc	103	gas-gaso	150	Hacker	200	2,000/2⅛"
Glenn Drlg Co	1	dsl	200	M-CSCO U-10	300	5,000
Tex-Mex Drlg Co	10	gas	—	Emsco GB-500	—	9,000
United Drlg Co (Texas)	2	gas-btne	600	Beth M-58	750	10,000
Martin County						
Coroco Drlg Co	2	gas-gaso	650	"Oilwell" 96	900	15,000
Davidson Drlg Co Inc	A	gas-btne	1000	Emsco J-1250	1000	14,000
Falcon Seaboard Drlg Co	Z-10	dsl	1100	Beth 950	1350	16,000
Matagorda County						
Bilbo-Redding Drlg Co Inc	9	stm	1050	Emsco ECC	1000+	15,000
	12	stm	900	Natl 34-8½	1000+	11,000
Houston Oil Well Serv Co	4	gas-btne	—	Ideco M-10,000	855	10,000
Turnbull & Zoch Drlg Co	1	stm	1600	Emsco	1000+	16,000
Maverick County						
J E Hillier	1	dsl	400	Sullivan 300-A	200	6,000/2⅛"
McMullen County						
Allen & Morris	8	stm	500	Emsco UBLS-541	200	12,500/5"
Buzzini Drlg Co	1	gas-btne	150	TIW	150	3,000
Menard County						
Fryer & Hanson Drlg Co	10	gas-btne	225	M-CSCO U-34	275	4,500
Tucker Drlg Co	1	gas	600	Brwstr N-55	—	9,500
Midland County						
B B M Drlg Co	1	gas-btne	950	Emsco GB-800	1050	14,000/4"
	2	gas-btne	1100	Emsco GB-800	1050	14,000/4"
	8	gas-btne	450	Beth M-58	650	9,000/4½"
	9	gas-btne	1300	M-CSCO U-30	1800	18,000
Bayer-Hunefelt Drlg Co	4	gas-btne	950	Brwstr N-85	950	12,500
Cactus Drlg Corp of Tex	3	gas-btne	800	Natl 80-B	—	12,500
Delta Drlg Co	3	gas-btne	900	Natl 100	800	12,000
Great Western Drlg Co	21	gas-gaso	840	M-CSCO U-914A	1260	15,000
	25	gas-gaso	775	M-CSCO U-914A	1530	15,000
O E Hall Drlg Co	5	gas	700	M-CSCO U-40	1210	12,000
Helmerich & Payne Inc	9	gas	1200	"Oilwell" 96	1100	14,000
	43	gas	900	"Oilwell" 76	1100	11,000
J E Jones Drlg Co	2	gas	500	M-CSCO U-15	663	7,500
Llano Drlg Co	1	dsl	1175	"Oilwell" 96	1200	15,000
	2	gas	—	Natl 100	975	14,000
Marcum Drlg Co	3	gas-btne	500	Emsco GA-500	700	9,000
Parker Drlg Co	16	gas	—	Natl 100	1400	14,000
	39	gas	—	Natl 100	1400	14,000
	43	gas	—	"Oilwell" 96	1400	15,000
	53	gas	—	Natl 75	1000	11,000
Rowan Drlg Co Inc	25	gas-btne	1260	Natl 100	1680	14,000
Sharp Drlg Co	34	gas	1350	Beth 1013	1350	16,000
A W Thompson Inc	10	gas	600	Clark Pr-1000	1050	13,500
Tri-Service Drlg Co	8	gas	900	"Oilwell" 76	900	10,000
Mills County						
Dixon Drlg Co	4	dsl-gas	200	Natl T-12	200	4,000
Mitchell County						
Cactus Drlg Corp of Tex	8	gas-btne	675	Brwstr N-7	675	9,000
Robinson Drlg Co (Colo. City)	3	btne	300	Beth MC-250	300	5,000/3½"
Montague County						
H O Grace Drlg Co	4	btne	—	—	—	7,500
Jack Grace Drlg Co	12	gas-btne	625	Wisn Atlas	1200	10,000
	20	gas-btne	370	Wisn Giant	700	8,000
Luke Grace Drlg Co	4	dsl-gas	300	Wisn SE Gnt	300	5,000
Roy Guffey Drlg Co	5	gas-btne	430	M-CSCO U-34	260	5,500
Gene McCutchin	8	gas	550	Natl 50	550	8,000
E W Moran Drlg Co	5	gas	370	Natl 50	650	7,500
Orm Drlg Co	1	dsl	600	M-CSCO U-15	—	9,500
Montgomery County						
Harry T Bryant Drlg Co Ltd	4	gas-btne	900	Natl 75	900	12,000
Falcon Seaboard Drlg Co	18	dsl	800	Whind B-85	975	11,000
C J Foster Drlg Co Inc	9	gas-LPG	—	Wisn Giant	412	8,000
Moore County						
Canadian River Drlg Co	1	dsl	300	M-CSCO U-34	300	6,000
Cree Drlg Co Inc	8	gas-btne	185	M-CSCO U-34	300	4,500
Urice Drlg Co	5	gas-btne	560	Wisn Giant	560	8,000
Wagner & Wyant Drlg Co Inc	3	dsl	175	M-CSCO U-34	300	5,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
Motley County						
Western Drlg Co Inc	18	btne	450	Crdwll O	225	8,000
Navarro County						
Stroube Drlg Co	—	btne	175	Mayhew	175	1,650/2⅛"
Travis Ward Drlg Co	1	dsl	600	Wisn Gnt	300	6,500
Newton County						
Clegg & Hunt	7	dsl	—	Natl 75	880	11,000
Howard Parker Co	4	gas-btne	300	Crdwll D	750	9,500
Timberland Expl Co	1	gas-btne	850	"Oilwell" 76	1050	10,500
Nolan County						
Robert M Bass Drlg Contr	4	gas-LPG	300	Wisn Giant	300	5,500
General Geophysical Co	31	dsl	—	—	500	7,500
Roy Guffey Drlg Co	6	gas-btne	560	M-CSCO U-15	560	7,500
A B See Drlg Co Inc	1	gas	400	Natl T-20	250	5,000
	3	gas	700	M-CSCO U-15	700	9,500
Nueces County						
Appell Petroleum Corp	2	dsl	520	Frnks SG-101	400	7,000
Flournoy Drlg Co	2	gas-btne	300	Wisn Giant	185	4,500
Frio Drlg Inc	3	gas-btne	800	Brwstr N-55	800	10,500
C G Glasscock Drlg Co	1	dsl	1200	Natl 110	1200	16,000
	5	dsl	1060	Natl 75	—	12,000
	9	dsl	400	Natl T-20	—	6,000
J C Drlg Co	6	gas-btne	450	Natl 50	450	7,500
Miller Bros & Bowling	1	gas-btne	495	Emsco G-300	—	5,500
Harold L Strader Drlg Co	Bge 401	btne	—	Brwstr N-4	—	5,500
Ochiltree County						
Arrow Drlg Co	9	gas	560	Emsco 500	—	8,000
Baker & Taylor Drlg Co	2	dsl	800	M-CSCO U-15	800	8,500
	5	gas-btne	1650	Natl 110	1650	15,000
	6	gas-btne	750	Emsco G-450	750	9,500
	7	gas-btne	1000	Natl 55	1000	10,500
Big Chief Drlg Co	33	gas	1250	Natl 55	1250	11,000
Graham-Michaelis Drlg Co	2	dsl	500	M-CSCO U-15	500	7,000
Lynn Drlg Co	2	gas-btne	425	Natl 75	700	10,000
Midwestern Drillers Inc	8	dsl	370	M-CSCO U-15	750	8,500
Moran Bros Inc	4	gas	1000	Wisn Titan	1200	14,000
Urice Drlg Co	2	gas-btne	840	Emsco GA-500	840	9,000
Wagner & Wyant Drlg Co Inc	4	gas-btne	500	M-CSCO U-15	700	9,000
Oldham County						
Baker & Taylor Drlg Co	3	dsl	800	M-CSCO U-15	800	8,500
Helmerich & Payne Inc	7	gas	500	Emsco GB-500-82	700	9,000
Orange County						
Producers Drlg Co Inc	2	dsl	2150	M-CSCO U-914B	1800	18,000
Palo Pinto County						
Bolin Oil Co & D H Bolin	9	gas	185	Wisn Super	145	4,000
E & H Drlg Co	1	gas	550	M-CSCO U-15	550	7,500
Ewing Drlg Co	1	btne	—	Emsco C-42	450	5,000
Red River Drlg Co	3	gas	185	Crdwll HL	165	8,500
Panola County						
D Thomason Drlg Co Inc	1	pwr	—	Brwstr	—	15,000
	2	pwr	—	Natl	—	10,000
Parker County						
Hunter Bros	2	gas-btne	700	Wisn Rdair	700	8,500
	3	gas-btne	400	Wisn Mogul	200	4,500
Pecos County						
Alan Drlg Co	3	gas	275	Wisn Mogul	145	3,500
Blount Drlg Corp	1	gas-btne	700	Wisn Gnt Rdair	700	8,500
	4	dsl	275	Brwstr N-4	275	5,500
Delta Drlg Co	2	gas-btne	400	Natl 50	450	7,000
	4	gas-btne	800	Natl 100	800	12,000
	36	gas-btne	900	Wisn Titan	900	15,000
Durham Drlg Co Inc	2	gas	500	M-CSCO U-15	675	9,000
Great Western Drlg Co	2	gas-gaso	500	Wisn Gnt Rdmstr	840	9,000
	9	gas	1053	M-CSCO U-20	1600	16,000
	44	dsl-elec	1400	M-CSCO U-1220	3000	25,000
Helmerich & Payne Inc	37	gas	1200	"Oilwell" 96	1450	15,000
Johnn Drlg Co	4	gas	375	M-CSCO U-15	600	8,500
J E Jones Drlg Co	3	gas	1070	"Oilwell" 76	1035	12,000
Parker Drlg Co	26	gas-elec	—	Natl 130	2000	20,000
	44	gas	—	Natl 125	1400	15,000
Penrod Drlg Co	12	gas-btne	—	—	1425	14,000
	32	dsl	—	—	1460	15,000
Pico Drlg Co	3	gas-btne	630	M-CSCO U-15	630	8,500
Rowan Drlg Co Inc	29	gas-btne	1200	Natl 100	1480	14,000
Texas Drlg Co	1	gas	300	Natl T-20	300	5,000/3½"
Polk County						
Howard Parker Co	3	gas-btne	500	Crdwll O	900	11,000
Potter County						
Drlg & Expl Co of Del Inc	24	gas	225	Wgnr-Mrhse	400	5,000
Reagan County						
Bolin Oil Co & D H Bolin	1	gas	225	Natl T-12	145	3,500
Brantly Drlg Co Inc	8	gas	675	Beth 450	870	11,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Carl B King Drlg Co of Tex	10	gas-gaso	1000	Natl 75	1000	12,500
Pool & Gerlich Drlg	D-3	gas	350	Emsco G-250	300	6,000
Sharp Drlg Co	41	gas	900	Beth MC-650	900	12,000
Texas R F O Inc	1	gas	325	Beth S-60	360	8,000
Tri-Service Drlg Co	2	gas	675	"Oilwell" 66	675	8,500
Reeves County						
Bickerstaff & Tibbets Drlg Co	2	gas	325	Brwstr N-4	320	6,000
Falcon Seaboard Drlg Co	2-11	gas-btne	1000	Beth 950	1020	16,000
Great Western Drlg Co	16	gas-gaso	775	M-CSCO U-914A	1260	15,000
Leatherwood Drlg Co	3	dsl	220	Natl T-20	—	6,000
Western Serv Drlg Co Inc	2	gas-btne	600	Natl 50-A	700	8,000
Refugio County						
Bilbo-Redding Drlg Co Inc	5	gas-LPG	900	Beth 450	—	11,000
Burdette Graham	1	gas-btne	738	Beth M-58	700	9,500
J & C Drlg Co	2	stm	600+	Emsco H-46	700+	9,000
	7	gas-btne	700	Emsco 500	600	9,000
Robinson-Wehmeyer Drlg Co	1	gas-btne	450	M-CSCO U-34	225	6,000
Roberts County						
Arrow Drlg Co	22	dsl	1200	Emsco 1000	—	14,000
Cree Drlg Co Inc	7	gas-btne	185	Emsco 250	300	4,500
Keating Drlg Co	6	gas-gaso	—	—	450	5,000
	18	gas-gaso	—	—	1150	14,000
Lynn Drlg Co	3	gas-btne	1000	Natl 75	1000	11,500
Triad Drlg Co	3	gas-btne	250	Beth S-45	250	5,500
	6	gas-btne	600	Beth M-58	600	10,000
Runnels County						
Frank Caraway Drlg Co	1	btne-gas	225	Beth S-50	—	5,000
Cooper Drlg Co	1	gas-btne	450	Natl 50	450	6,500
Johnn Drlg Co	2	gas	375	M-CSCO U-15	400	7,500
	5	gas	375	M-CSCO U-15	600	8,500
Johnson-Gadbois Drlg Co	5	gas	410	Wisn Mogul	—	4,000
St John Drlg Co	2	gas	300	Natl 50	450	7,000
Tex-Mex Drlg Co	9	gas	400	Emsco 250	450	5,500
Rusk County						
Milton Crow Inc	5	gas	600	Brwstr N-7	400	7,500
Maxwell Herring Drlg Corp	3	gas	600	Wisn Gnt Rdair	600	9,500
South States Drlg Co	3	dsl	330	Emsco GB-350	520	8,000/4"
	4	dsl	275	Emsco GA-350	480	7,000/4"
Tex-Mex Drlg Co	6	gas-btne	1200	Wisn Titan	1200	13,000
San Jacinto County						
B B M Drlg Co	3	stm	—	Emsco UBLS-54-10	—	14,000
San Patricio County						
Armstrong & Horn Drlg Co	1	dsl	450	Brwstr N-45	—	7,000
Conroe Drlg Co	2	gas-btne	675	M-CSCO U-15	675	9,500
Harkins & Co	6	gas-gaso	675	M-CSCO U-15	675	9,500
J & C Drlg Co	3	gas-btne	450	Natl 50	450	7,500
Kirkwood & Morgan Inc	11	dsl	900	Brwstr N-7	900	11,500
Miller Bros & Bowling	3	gas-btne	850	Emsco GC-500	—	9,000
Schleicher County						
Fortune Drlg Corp	1	gas	325	Beth S-55C	524	7,500
Great Western Drlg Co	5	gas-gaso	500	M-CSCO U-15	770	7,500
Tucker Drlg Co	4	dsl	610	Beth J-55	—	9,500
	5	gas	620	Crdwll O	620	9,500
Scurry County						
Calco Drlg Co	4	gas-btne	215	Beth Breeze	200	5,500
Dearing Inc	4	gas-btne	—	Wisn	—	4,000
Empire Drlg Co	8	gas	500	M-CSCO U-15	675	8,500
John Grappe Drlg Co	1	gas-btne	520	Beth	—	8,500
	2	gas-btne	720	Beth	—	13,000
Hack Drlg Co	3	btne	—	M-CSCO U-15	412	8,500
Rheay & Reynolds Drlg Co	5	gas	350	Natl 75	1200	7,000
Robinson Drlg Co (Colo City)	1	btne	550	M-CSCO U-15	550	9,000/3½"
	2	btne	600	M-CSCO U-15	600	9,000/3½"
	4	btne	235	Crdwll KL-210	135	3,500/3½"
Shackelford County						
Cooper Drlg Co	2	gas-btne	600	Wisn Gnt	600	7,500
Dearing Inc	3	gas-btne	—	Wichtex	—	3,000
Gore Drlg Co	1	dsl	640	Shovel Spl	—	7,500
	2	dsl	320	Beth	—	5,000
	3	gas	254	Joy 200-A	—	2,500/2⅞"
A V Jones & Sons	2	dsl	600	M-CSCO U-15	600	8,500
	4	dsl	400	Wisn Mogul	180	3,500
Low Drlg Co	1	btne	—	Emsco	290	7,000
H F Pettigrew Drlg Co	1	—	—	Mayhew Prtble	—	—
Shelby County						
Gibson Drlg Co	5	gas-btne	275	Wisn Gnt	275	6,000
Sherman County						
Cree Drlg Co Inc	6	gas-btne	255	Wisn Gnt	300	5,000
Smith County						
Barnwell Drlg Co Inc	7	dsl	800	Brwstr N-75	800	12,000
Robert M Bass Drlg Contr	3	gas-LPG	400	Wisn Gnt Rdair	600	8,500
B G Byars Power Drlg Co	1	gas-btne	1170	Beth MC-450	775	11,000
Delta Drlg Co	40	gas-btne	325	Wisn Rdr Gnt	690	8,000
Gibson Drlg Co	3	gas-btne	300	Wisn Gnt	275	6,000
Halbert Drlg Co	2	gas-btne	285	Wisn Rdair	445	6,500
Pyburn Drlg Co	1	dsl	500	Ideco M-750	750	9,000
Tex-Mex Drlg Co	7	gas	—	Emsco GB-350	—	7,000
	12	gas	—	M-CSCO U-15	—	9,000
Trant Drlg Co	3	stm	—	—	—	15,000
Starr County						
Appell Petroleum Corp	4	gas-gaso	315	Wisn Mogul	175	4,000
Holmes Drlg Co	7	gas-gaso	—	Beth MC-450	1000	11,000
Viking Drlg Co	3	gas-gaso	800	M-CSCO U-15	600	9,000
Stephens County						
King Edwards (Edwards Drlg Co)	3	gas-gaso	600	M-CSCO U-15	600	9,000
Irish Drlg Co Inc	4	btne	360	Wichtex R-5	—	4,000
K & H Drlg Co	2	gas	200	Wisn Mogul	400	5,000
A F Knappenberger	1	gas	450	Emsco GA-500	500	7,500
R-G Drlg Co	5	gas-gaso	—	Wilson	650	8,000
Stephens Oil & Gas Corp	1	gas	225	M-CSCO U-34	183	4,500
Taylor Expl Co Inc	7	btne	—	Mayhew	—	1,200
Wright Clark & Senkel Inc	11	gas-btne	450	Wisn Gnt	450	7,500
Sterling County						
Great Western Drlg Co	38	gas-gaso	320	M-CSCO- U-15	675	7,500
Rheay & Reynolds Drlg Co	6	gas	300	Natl 50	750	7,000
Stonewall County						
Bayer-Hunefelt Drlg Co	3	gas-btne	550	M-CSCO U-15	550	7,500
Roy Guffey Drlg Co	4	gas-btne	560	M-CSCO U-15	560	7,500
Herb Expl Co	2	btne	—	Failing 1500	—	1,750/2⅛"
	3	btne	—	Failing 1500	—	2,000/2⅛"
T F Hunter Estate	1	gas-btne	700	Wisn Rdair	700	8,500
W B Omohundro	8	btne	700	Wisn Rdair	—	8,000
	10	btne	300	Brwstr N-3	—	4,500/3½"
St John Drlg Co	3	gas	400	Brwstr N-55	570	7,500
Thomas & Billups Drlg Co	1	btne	450	Emsco 300	450	6,000
Sutton County						
Great Western Drlg Co	11	dsl	353	Wisn Gnt Rdmstr	900	9,000
Johnn Drlg Co	9	gas	375	Brwstr N-45	400	7,000
Pico Drlg Co	2	gas-btne	600	Brwstr N-7	600	8,500
Tucker Drlg Co	3	gas	600	Ideco TC-600	—	9,500
Taylor County						
Black Drlg Co	1	dsl	275	Frnks	250	4,000/3½"
Dixon Drlg Co	1	dsl-gas	260	Natl T-20	260	5,000
H O Grace Drlg Co	3	btne	—	—	—	6,000
J E Miller Drlg Contr	1	btne	165	Natl T-8-S	145	3,400/3½"
	2	btne	200	Natl T-12	165	4,000
Norman Drlg Corp	2	dsl	330	M-CSCO U-10	350	5,000
Sojourner Drlg Corp	5	btne	225	Natl T-8-S	—	3,250
West Central Drlg Co	8	gaso-btne	325	Wisn Rdair	975	10,000
	9	gaso-btne	225	Spencer	145	3,000
Terrell County						
Choya Drlg Co Inc	4	gas-btne	1400	Emsco J-1400	1400	15,000
Great Western Drlg Co	18	dsl	955	M-CSCO U-914A	1800	15,000
Helmerich & Payne Inc	48	gas-btne	1200	Natl 110	1300	15,000
Layton & Newell Drlg Co	4	gas	600	Emsco J-1400	1900	17,000
Terry County						
Robinson Brothers Drlg Co	2	gas	800	Brwstr N-75	800	10,000
Midland Drlg Co	1	gas-btne	600	M-CSCO U-15	600	8,000
Milhoan Drlg Co	6	gas	600	M-CSCO U-15	—	8,000
Throckmorton County						
Alan Drlg Co	1	gas	550	Wisn Gnt	850	8,000
Harvey Drlg Co	5	gas-btne	750	Wisn Giant	800	8,500
R-G Drlg Co	1	gas-gaso	—	Wilson	650	6,500
	2	gas-gaso	—	Wisn	650	8,000
	3	gas-gaso	—	Wilson	450	6,500
Schulz & Brannan Drlg Co	1	dsl	400	Wisn Mogul	400	5,000
Sheets & Walton Drlg Co	3	pwr	365	Brwstr N-4	285	5,000
Taylor Expl Co Inc	1	btne	—	Mayhew	125	3,000
	2	gaso	—	Failing	—	1,500
	8	btne	—	Failing	—	2,000
Titus County						
W B Hinton	1	stm	750	Alco BIW-11	—	10,000
Tom Green County						
Dixon Drlg Co	3	gas	500	Natl 50	520	7,500
Pool & Gerlich Drlg	D-2	gas	260	M-CSCO U-34	300	5,000
A W Thompson Inc	8	gas	450	Beth 58	750	10,000
Tucker Drlg Co	2	gas	425	Brwstr N-4	—	6,500
Tyler County						
Bilbo-Redding Drlg Co Inc	1	dsl	750	Whind 65	550	9,500
	11	gas-LPG	550	Wisn Gnt	290	8,000
Timberland Expl Co	2	gas-btne	1100	"Oilwell" 76	1200	12,500
Upshur County						
Gibson Drlg Co	2	gas-btne	226	Wisn Mogul 42	145	5,000

PUSH...not pull...raises this all-new "Oilwell" Lever-Lift Mast!



Look at this schematic drawing!

See how the lifting power from the draw works is first applied through the wire line system at a point near the center of the mast while in horizontal position . . .

. . . and how this power, using leverage principles, pushes against the front legs until the mast reaches an upright drilling position—approximately one degree from vertical.

The lifting levers then lock into place with an automatic wedge-type mechanism and become the front legs of the mast—an integral part of the unit.

. . . and note these design features

1. Main tower consists of five sections which may be transported on two semi-trailers and one truckload.
2. Sections are assembled at ground level by means of "T" bolts and patented built-in wedge-lock fasteners which tighten in use.
3. Raising mechanism is on the forward part of the substructure and operates in front of the hinge points, permitting use with any make draw works.
4. Snubbing is unnecessary. An overtravel stop makes it impossible to pull this mast over backwards.
5. Patented cross-over crown block assembly, with fast line and dead line outside the mast, equalizes leg loading. It also permits stringing the traveling block with flat side facing and fast line away from the derrickman.
6. Eccentric hinge pins in each leg facilitate centering and leveling of the crown block.

For complete information . . . contact your "Oilwell" representative. He will be glad to give you the full story.

USS and "Oilwell" are registered trademarks

"OILWELL"

Oil Well Supply Division of USS **United States Steel**

Branches Serving All Oil Fields **Executive Offices**—Dallas, Texas **Area Offices**—Calgary, Alberta · Casper, Wyoming · Columbus, O. Dallas, Texas · Houston, Texas · Tulsa, Okla. · Los Angeles, Calif. **Export Office**—30 Rockefeller Plaza, New York 20, N. Y.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Upton County						
B B M Drlg Co	4	gas-btne	400	Natl 50	600	8,500/3½"
Fortune Drlg Corp	2	gas	300	M-CSCO U-15	590	7,500
Hack Drlg Co	1	btne	—	M-CSCO U-15	412	8,500
Hewgley Drlg Co	2	gas-btne	—	Ideco	1400	14,000
La Mance Drlg Co	2	btne	700	M-CSCO U-15	—	9,500
McQueen & Stout Drlg Co	10	LPG	225	Crdwll RL	185	4,500
Penrod Drlg Co	1	gas-btne	—	—	1800	15,000
Sharp Drlg Co	37	gas	900	Beth MC-450	900	12,000
Carl J Westlund Inc	6	gas-btne	975	Wisn Titan	—	12,000
	7	gas-btne	650	Wisn Rdair	—	8,500
Wilbanks & Rutter Drlg Co	1	gas	1050	M-CSCO U-40	1050	10,000
Van Zandt County						
Big Chief Drlg Co	5	gas	1545	Emsco 1250	1545	15,000
Victoria County						
Field Drlg Co	2	dsl	1000	M-CSCO U-15	750	10,000
Glenn Drlg Co	3	gas	145	Crdwll S	145	4,000
J & C Drlg Co	8	gas-btne	800	Beth 650	800	12,000
Turnbull & Zoch Drlg Co	7	gas-btne	630	Ideco Rambler	630	10,000/3½"
Ward County						
Hissom Drlg Co	2	gas	400	M-CSCO U-34	500	6,000
	4	gas	400	M-CSCO U-34	350	5,000
Keating Drlg Co	16	gas-gaso	—	—	450	6,500
Robinson Bros Drlg Co	4	gas	300	Brwstr N-45	450	6,500
Triad Drlg Co	2	dsl	300	Beth S-45	300	6,000
Western Serv Drlg Co Inc	7	gas-btne	600	Natl 50	700	7,000
	13	gas-btne	550	Beth S-45-E	350	5,000
Wharton County						
Field Drlg Co	4	dsl	520	Beth Breeze	260	6,500
Wheeler County						
Falcon Seaboard Drlg Co	33	gas	1050	Beth 1013	1350	16,000
Latexo Drlg Co Inc	3	dsl	260	Brwstr N-4	260	5,000
Wichita County						
Bolin Oil Co & D H Bolin	10	dsl	330	Wisn Gnt	300	4,500
Harvey Drlg Co	6	gas-btne	500	Wisn Giant	500	7,500
Hull Oil Co	1	btne	140	Wlkr-Nr R-2	—	2,150
Meredith Drlg Co	2	btne	500	Wisn Gnt	225	7,500
E W Moran Drlg Co	6	gas	225	Wisn Mogul	160	4,500
W B Omohundro	9	btne	550	Wisn Rdair	—	6,500
Wilbarger County						
Bolin Oil Co & D H Bolin	4	gas	350	Wisn Gnt	500	7,500
T V Gorman Drlg Contr	1	dsl	200	Wichtex R-3	200	3,000
	2	dsl	300	Wisn 38 Torcair	300	4,500
Gray Drlg Co	1	gas-gaso	220	Wisn Gnt Rdair	450	5,500
Willacy County						
Flournoy Drlg Co	3	gas-btne	353	Brwstr N-45	320	6,500
Wilson County						
Kirkwood & Morgan Inc	10	dsl	400	Wisn Mogul	400	7,000
Pegg Bros Drlg Co	3	gas-btne	90	—	90	1,500/2⅛"
Winkler County						
Robert M Bass Drlg Contr	2	gas-LPG	350	Brwstr N-45	350	7,000
Big West Drlg Co	11	gas-btne	500	M-CSCO U-20	900	14,000
Blount Drlg Corp	3	gas-btne	275	M-CSCO U-34	175	5,000
Bolin Oil Co & D H Bolin	2	gas	225	Natl T-12	185	4,500
Camden Drlg Co	1	dsl	300	Natl T-20	300	5,000
Danforth Drlg Co	1	dsl	240	Ideco H-30	350	5,000
Davidson Drlg Co Inc	D	btne	315	Wisn Mogul	600	7,500
Dixilyn Drlg Corp	3	gas	950	Natl 100	950	14,000
Donnell Drlg Co	14	btne	—	Ideco H-40	370	4,000
Frontier Drlg & Prod Co	8	dsl	300	Brwstr N-4	300	5,000
Gardner Bros Co Inc	12	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	12	gas-gaso	1350	M-CSCO U-20	1755	16,000
King-Phillips Inc	3	dsl	622	Ideco H-40D	—	5,500/4"
	4	gas	700	Beth S-45-E	350	6,500
Laughlin-Porter Drlg Co Inc	1	gas	800	Natl 50	—	7,000
	3	gas	416	Natl T-20	—	5,000
	6	gas	1000	Wisn Titan	—	14,000
Leatherwood Drlg Co	1	gas	600	Ideco 750	—	10,000
	4	gas	450	Crdwll	450	6,000
	7	gas	750	Wilson	750	10,000
Lowe Drlg Co	11	LPG	225	Crdwll RL	185	4,500
McQueen & Stout Drlg Co	111	gas	1200	Emsco	1200	14,000
Dale Mount Drlg Inc	1	gas	550	Wisn Gnt	550	7,000
Ormand Drlg Co Inc	33	gas	—	Natl 75	1000	11,000
Parker Drlg Co	D-1	gas	260	M-CSCO U-34	300	5,000
Pool & Garlich Drlg	38	gas	1200	Beth M-58	1200	10,000
Sharp Drlg Co	43	gas	2000	Beth 1013	2000	20,000
	44	dsl	1000	Beth S-45	300	5,000
A W Thompson Inc	5	gas	650	Beth 810	1050	13,500
Warton Drlg Co	4	gas	700	Emsco J-750	1000	12,000
Western Serv Drlg Co Inc	12	dsl	250	Natl T-20	520	4,000
Wise County						
Akin & Dimock	2	dsl	300	Beth S-55	420	7,000
Bolin Oil Co & D H Bolin	6	gas	350	Wisn Gnt Rdair	250	6,500
Jess P Cross Drlg Contr	1	gas-btne	250	Wisn Mogul	230	4,500/3½"
Frank Frawley Drlg Co	5	gas	—	M-CSCO U-15	625	8,500
Jack Grace Drlg Co	5	gas-btne	500	Wisn Atlas	700	10,000
	17	gas-btne	370	Wisn Gnt	700	8,000
Luke Grace Drlg Co	7	dsl-gas	600	Wisn Air Atlas	600	12,500
	18	dsl-gas	600	M-CSCO U-15	600	9,000
Hamman Oil & Ref Co	7	dsl	340	Brwstr N-75	600	11,000
John W Harris Drlg Co	1	gas	500	Hou Prtble	450	6,500
	2	gas	500	Emsco GC-500	500	8,000
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
	2	gas-btne	150	Wisn Super	150	3,500
	4	gas-btne	150	Crdwll K-200	150	3,500
E W Moran Drlg Co	4	gas	300	M-CSCO U-15	650	7,500
Paine Drlg Co	6	btne	500	Wisn Giant	500	7,000
	7	dsl	450	Wisn Giant	450	7,000
Pan-Tex Drlg Co	1	gas	350	Brwstr N-45	400	6,500
Trio Drlg Co	1	gas	520	Wisn Giant	—	8,000
	2	gas	520	Natl 50	—	6,500
	3	gas	450	Wisn Giant	—	6,500
	4	gas	450	Natl 50	—	6,500
Walters Drlg Co Inc	12	dsl	—	Mayhew 1000	300	400/2⅛"
Wright Clark & Senkel Inc	18	gas-btne	450	Wisn Gnt Rdmstr	450	7,500
Wood County						
Ace Drlg Co	2	gas	680	Emsco G-500	500	9,000
Robert M Bass Drlg Contr	1	gas-LPG	500	Wisn Rdair	800	10,000
M J Delaney Co	21	gas-btne	500	Wisn Titan	650	9,500
	25	stm	—	Emsco UBLS 54	—	15,000
	28	gas-btne	500	"Oilwell" 96	1000	14,000
Delta Drlg Co	15	gas-btne	530	M-CSCO U-15	600	8,000
Gibson Drlg Co	1	gas-btne	275	Wisn Mogul 42	265	5,000
Maxwell Herring Drlg Corp	2	gas	700	Wisn Gnt Rdair	700	10,500
Yoakum County						
B B M Drlg Co	6	gas-btne	400	Emsco GB-500	650	10,000/3½"
Gardner Bros Drlg Co Inc	14	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	4	gas	307	M-CSCO U-15	800	9,000
Marcum Drlg Co	1	gas-btne	325	M-CSCO U-15	675	8,000
	6	gas-btne	900	Natl 75	1050	10,000
Fred Pool Drlg Co	1	gas	580	M-CSCO U-15	600	7,500
Sharp Drlg Co	32	gas	1200	Beth MC-450	1200	12,000
Western Drlg Co Inc	11	dsl	288	Emsco 350	375	6,500
Young County						
Bolin Oil Co & D H Bolin	3	gas	350	Wisn Giant	225	5,000
R W Darden Drlg Co	1	gas	145	Wichtex R-3	—	3,000
E & H Drlg Co	2	gas	275	M-CSCO U-34	225	4,500
King Edwards (Edwards Drlg Co)	2	gas-gaso	600	M-CSCO U-15	600	9,000
J W Hastings Drlg Co	4	gas-btne	330	Wisn Torcair	220	5,000
	5	gas-btne	864	Wisn Gnt Rdr	864	8,200
Oney Drlg Co	5	gas	250	Crdwll S	200	4,000
Louis Pitcock Drlg Co	1	gas-btne	225	Beth S-55	600	7,500
	7	gas-btne	225	Beth S-45	3250	4,000/3½"
Taylor Expl Co Inc	3	gaso	—	Mayhew	75	1,000
	4	gaso	—	Mayhew	75	1,000
Varner-Neill Drlg Co	1	gas	500	Wisn Giant	450	6,000
Zavala County						
Bay City Drlg Co Inc	2	gas-btne	300	M-CSCO U-34	300	5,000
UTAH						
Carbon County						
Falcon Seaboard Drlg Co	MA-1	gas-btne	300	M-CSCO U-35	210	6,500
Emery County						
Jet Drlg Co Inc	2	dsl	600	Brwstr N-7	600	9,000
Moran Bros Inc	7	gas	700	Wisn Gnt	750	9,500
Grand County						
Expl Drlg Co	11	gas	800	Beth S-60	480	8,000
Hewit-Gulick Drlg Co	3	gas-btne	600	Natl 50-CA	900	8,000
San Juan County						
Arapahoe Drlg Co	2	gas-btne	300	Natl T-32	320	6,000
	4	gas-btne	375	Natl 50-A	680	8,000
Calvert Drlg Inc	20	dsl	350	Ideco H-525	600	8,500
Camay Drlg Co	3	dsl	560	Natl 50-A	450	8,500
Rocky Mt Div	6	dsl	260	Johnson	450	5,000
Carmack Drlg Co	1	dsl	680	Natl 50-A	450	8,000
D-K Drlg Co	3	gas	500	Natl 50	500	6,500
Exeter Drlg Co	3	btne	630	Natl 50-A	630	8,500
Expl Drlg Co	8	gas	670	M-CSCO U-15	600	8,000
	15	gas	800	Natl 75-CA	900	11,000
Great Western Drlg Co	14	dsl	320	M-CSCO U-15	800	9,000
	30	dsl	500	M-CSCO U-15	750	7,500
	42	dsl	500	Emsco G-500	800	9,000

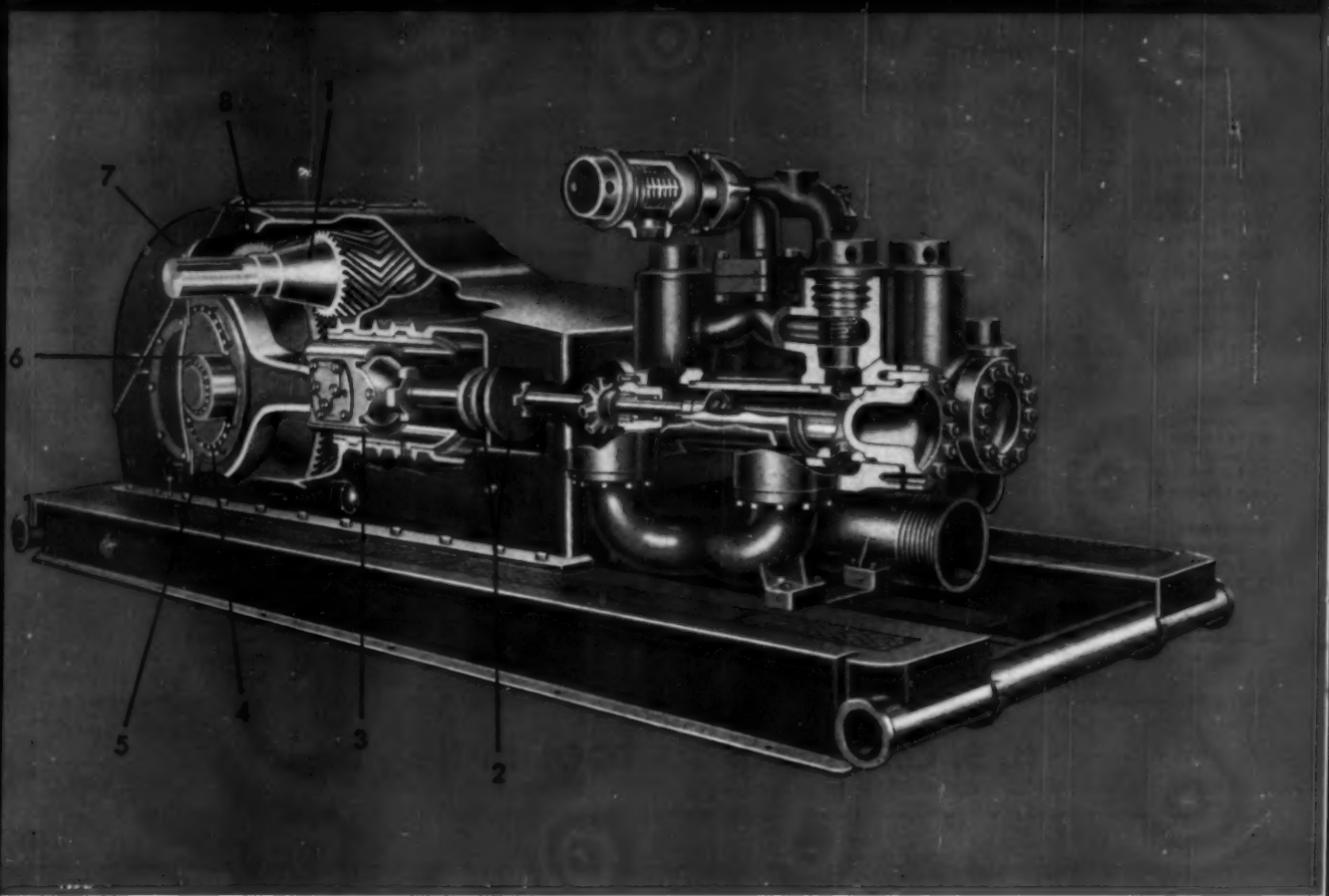
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Kerr-McGee Oil Ind Inc	1	gas	825	M-CSCO U-15	832	10,000
R L Manning Co	4	gas-btne	600	Emsco 450	450	7,000
	12	gas-btne	550	Emsco GA-350	450	7,000
Moran Bros Inc	3	gas	400	Emsco GB-350	550	8,000
	8	gas	700	Wisn Gnt	750	9,500
	9	gas	700	"Oilwell" 66	750	9,500
	16	gas	650	M-CSCO U-15	600	7,500
Mountain States Drlg Co Inc	6	dsl	600	Natl 50	—	7,500
Rhodes Drlg Co	5	gas	450	M-CSCO U-15	675	9,000
	11	gas	240	Emsco 350	360	5,000
The R W Rine Drlg Co	2	dsl	520	Brwstr N-7	600	8,500
	6	dsl	520	Brwstr N-75	750	12,000
Uintah County						
A O Bullock Drlg Co	3	gas	370	Beth Twister	—	7,500
Kerr-McGee Oil Ind Inc	23	gas	650	Natl 50	556	9,000
Mountain States Drlg Co Inc	4	gas-dsl	600	Emsco GB-500	—	9,000
Washington County						
Miller & York	1	dsl	275	Frnks Clipper	225	3,500
WASHINGTON						
King County						
Miracle & Wooster Drlg Co	—	gas	850	M-CSCO U-15	500	7,500
WEST VIRGINIA						
Jackson County						
Delta Drlg Co	27	dsl	380	Emsco GA-350	350	6,000
Nicholas County						
Gordon Drlg Co	10	gas-LPG	600	"Oilwell" 66	500	9,500
Pocahontas County						
S W Jack Drlg Co	2	dsl	800	M-CSCO U-15	800	8,500
Roane County						
Eakle & Holder Drlg Co	5	ds	600	Natl 50	600	8,500
Tucker County						
S W Jack Drlg Co	4	gas	1000	M-CSCO U-15	1000	10,000
Wood County						
Delta Drlg Co	29	dsl	750	Emsco J-750	750	12,000
WYOMING						
Albany County						
Carpenter-Trant Drlg Co	9	dsl	250	Franks	300	5,000
Big Horn County						
Anschutz Oil Co Inc	7	gas	900	M-CSCO U-15	650	8,500
A O Bullock Drlg Co	1	gas	225	Wichtex R5	—	3,500
R L Manning Co	8	dsl	550	Emsco G-500	550	7,500
	16	gas-btne	475	Natl T-32	450	6,000
Campbell County						
Anschutz Oil Co Inc	9	gas	800	Natl 50-A	600	8,500
Delta Drlg Co	23	dsl	520	Emsco GA-500	500	8,000
Hewit-Gulick Drlg Co	1	dsl	970	Natl 50-A	600	8,000
J D Sprecher	6	dsl	750	Emsco A-550	750	9,000
True Drlg Co	8	gas-gaso	500	Natl 50	500	7,500
Carbon County						
Roden & McRae Drlg Corp	1	dsl	625	Emsco GA-350	570	7,000
	6	dsl	275	Frnks Rocket TD44	275	2,000
Crook County						
True Drlg Co	6	gas-gaso	700	Beth Twstr	700	8,500
	10	gas-LPG	675	M-CSCO U-15	675	9,500
	11	gas-btne	800	Natl 75	800	11,000
Fremont County						
Kerr-McGee Oil Ind Inc	28	gas	770	Natl 75	832	11,500
R L Manning Co	2	gas-btne	600	Emsco 300	300	5,500
	17	gas-btne	1045	Emsco GC-500	770	10,000
Taylor Expl Co Inc	6	btne	—	Failing	—	1,200
Goshen County						
A O Bullock Drlg Co	2	gas	225	Crdwll S	—	4,000
Hot Springs County						
Arrow Drlg Co	14	gas	600	Wisn	—	8,000
Mountain States Drlg Co Inc	17	dsl	540	Natl T-32	—	6,000
Roden & McRae Drlg Corp	5	gas	360	Emsco GA-250 T	425	6,500
Signal Drlg & Expl Inc	4	gas	300	Ideco H-25	300	4,200
Johnson County						
Carpenter-Trant Drlg Co	5	dsl	900	Brwstr	900	12,000
R L Manning Co	7	gas-btne	750	Emsco G-500	750	8,000
Lincoln County						
Fitzpatrick Drlg Co Inc	4	gas-btne	900	Wisn Titan Rdr	900	12,500
Kerr-McGee Oil Ind Inc	31	gas	1000	Natl 100	1680	15,000
R L Manning Co	11	gas-btne	1080	Emsco J-1000	1305	13,000
Rowan Drlg Co Inc	24	gas-btne	504	Natl 50	1077	8,500
Natrona County						
Falcon Seaboard Drlg Co	9	gas-btne	325	M-CSCO U-15	450	8,500
True Drlg Co	7	dsl	185	Failing	165	3,500
Park County						
Carpenter-Trant Drlg Co	6	dsl	450	Wisn Giant	640	7,500
R L Manning Co	15	dsl	540	Emsco GB-250	340	6,000
Mountain States Drlg Co Inc	9	gas-dsl	1400	Natl 125	—	15,000
Roden & McRae Drlg Corp	2	dsl	265	Emsco GA-300	270	4,500
Sublette County						
Fitzpatrick Drlg Co Inc	1	gas-btne	550	M-CSCO U-15	550	8,250, 4"
R L Manning Co	5	gas-btne	750	Emsco G-500	750	8,000
Mountain States Drlg Co Inc	2	gas-dsl	1000	Emsco J-750	—	10,000
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500
Sweetwater County						
Brack Drlg Co Inc (Colo)	6	dsl	—	M-CSCO U-15	606	8,500
Carpenter-Trant Drlg Co	8	btne	800	Wisn Spr Gnt	1320	12,000
Mountain States Drlg Co Inc	3	gas-dsl	600	Natl 50-A	—	7,500
Nye & Snell Drlg Co	3	gas	600	Wisn Atlas	800	11,000
Reserve Drlg Co Inc (Casper)	3	gas-LPG	500	Natl 50	500	7,500
J D Sprecher	4	dsl	1000	Natl 80-B	1000	12,000
Teton County						
R L Manning Co	10	gas-btne	1275	Emsco J-750	1125	11,000
True Drlg Co	4	gas-gaso	400	Emsco GA-250	250	6,000
Washakie County						
Delta Drlg Co	18	dsl	600	Natl 75	650	9,500
	28	dsl	350	Frnks SAL-6000	600	5,000
Don Johnston Drlg Co	5	gas-btne	900	Natl 75	900	10,000
R L Manning Co	6	gas-btne	900	Emsco GB-800	1125	11,000
Mountain States Drlg Co Inc	14	dsl	800	Ideco M-1000	—	10,000
Rowan Drlg Co Inc	31	gas-btne	900	Natl 75	1149	11,000

U. S. Contract CABLE TOOL Drilling Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALABAMA						
Chas E Hipp Co	14	btne	145	4000	5000	B Erie 36-L
Hamilton County						
Harry L Cullet	1	gas-gaso-btne	125	3000	3500	Crdwll H
	3	gas-gaso-btne	250	7000	7500	Spec
Talladega County						
Harry L Cullet	2	gas-gaso-btne	150	5000	5500	Star Spdr
ARIZONA						
Mohave County						
Aldridge & Stroud Inc	6	LPG	145	4500	4500	Wichita 61
ARKANSAS						
Lafayette County						
Dudley C Beene Inc	3	gas	145	5000	10,000	Wisn Mogul
Union County						
H F Hatcher & Son	1	gas-gaso-btne	140	4000	5500	Crdwll KL-225
CALIFORNIA						
Los Angeles County						
Al Godfrey Drlg Co	1	LPG	160	2500	3000	Godfrey
Ventura County						
United Drlg Co	2	gas	75	2000	—	Keystone A-50
COLORADO						
Huerfano County						
Western Drlg Co Inc	5	btne	185	—	—	B Erie 48-L
	7	dsl	185	—	—	B Erie 48-L
La Plata County						
Signal Oilfield Service	13	dsl	—	—	8000	Crdwll RL
Morgan County						
Signal Oilfield Service	5	dsl	200	—	8000	Crdwll RL
Weld County						
Signal Oilfield Service	4	dsl	200	—	8000	Crdwll RL

Reliable

Field Performance..



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Continental-Emsco Power-End *design*

By the cross sectional drawing, you can see why Tool Pushers and Drillers place so much reliance in the power ends of Continental-Emsco slush pumps. In addition to their rugged construction, these power ends are surprisingly lightweight due to their *Fabriform* construction. In this new concept of pump design, the conventional heavy, bulky casting has been replaced by steel plates, formed and fabricated into a compact, rigid frame. You get *more horsepower per pound* than in any other slush pump.

POWER END FEATURES

1. One-Piece, Forged-Steel Pinion and Shaft
2. Packing Gland and Rubber Baffle Keeps Mud From Power End
3. Replaceable Crosshead Slippers and Frame Guides
4. One-Piece Eccentric Straps, Equipped With Large-Diameter, High Capacity, Retainer-Type Roller Bearings
5. Combination Splash-and-Pressure Lubrication System
6. Roller Bearings Used Throughout
7. All-Steel, Fabriform Constructed Power End
8. Demountable, Forged-Steel Herringbone Gear

Continental-Emsco "D" Series Slush Pumps give you all these wanted, needed fluid end features

- ★ Precharged Pulsation Dampener
- ★ 360° Swiveling Screen, Protects Discharge
- ★ Heavy, Coarse-Pitch Threaded Valve-Pot Covers
- ★ Cylinder Head Lock Liner

Shear Relief Valve

Liners Packed at Both Ends, Exposed to View

Screw-Type Stuffing Boxes

Two-Piece Fluid End on DA-850 and D-1000

Four-Runner Skid, Standard on D-700, DA-850, D-1000

★ All models except D-175 and D-300

MANUFACTURED BY

CONTINENTAL-EMSCO

Serving the Oil and Gas Industries .. Worldwide

SP711

CONTINENTAL-EMSCO COMPANY • A Division of The Youngstown Sheet and Tube Company
General Offices: DALLAS, TEXAS • Plants: HOUSTON • GARLAND • LOS ANGELES

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ILLINOIS						
Christian County						
LaMac Drlg Co Inc	1	dsl	600	4700	—	Wlsn Gnt
	2	gas	75	4000	4500	B Erie 24-L
V S & S Drlg Co	1	gas	—	—	2000	Wichtex
Clay County						
Perrine & Perrine Drlg Contr	2	btne	145	—	6000	B Erie 36-L
J W Rudy	3	btne	130	—	4000	Crdwll K
Shulman Bros	2	gas-gaso	—	4000	—	Crdwll H
Coles County						
Cummins Drlg Co	C-6	gas-gaso	78	2500	3500	B Erie 28-L
Crawford County						
W L Dillier	1	gas	65	1500	2000	B Erie 60-L
Fayette County						
Cummins Drlg Co	C-1	gas-gaso	65	1500	2000	B Erie 24-L
	C-2	gas-gaso	65	1500	2000	B Erie 24-L
	C-3	gas-gaso	65	1500	2000	B Erie 60-L
	C-4	gas-gaso	65	1500	2000	B Erie 60-L
	C-7	gas-gaso	45	1000	1250	B Erie 22-W
Gallatin County						
C W Strotman Drlg Co	3	gas	145	3600	4500	Crwdll H
V S & S Drlg Co	3	gas	—	3500	3500	Cooper
Hamilton County						
C E Brehn	8	btne	184	—	5000	Crdwll K
Kankakee County						
Moran Bros Inc	4	gas-LPG	175	4500	7000	B Erie 36-L
Lawrence County						
Payne Bros Drlg Co	3	dsl	150	3000	4000	B Erie 36-L
Marion County						
E H Adams Drlg Co	2	gas-btne	125	2000	3000	Franks
Graham Powell	1	btne	500	4200	4200	B Erie 36-L
Richland County						
Don Slape Drlg Co	1	btne	—	—	—	Crdwll K
Saline County						
C E Brehn	4	btne	184	—	5000	Crdwll K
Wabash County						
Payne Bros Drlg Co	2	dsl	150	3000	4000	B Erie 36-L
INDIANA						
Gibson County						
Houchins Drlg Co	2	gaso	150	—	3500	Frnks Spddr
South State Drlg Corp	2	dsl	110	—	10,000	Crdwll R
C W Strotman Drlg Co	4	gas	130	3000	3500	Crdwll K
Pike County						
Payne Bros Drlg Co	1	dsl	150	3000	4000	B Erie 36-L
Posey County						
South State Drlg Corp	3	dsl	110	—	4200	Cooper
C W Strotman Drlg Co	1	gas	145	3600	4500	Crdwll H
	2	gas	175	3500	4000	B Erie 36-L
Vigo County						
Cummins Drlg Co	C-5	gas-gaso	78	2500	3500	B Erie 28-L
IOWA						
Dallas County						
Kirby Oil Ind	—	gas-gaso	145	—	—	B Erie 28-L
KANSAS						
Barber County						
Patton Drlg Co Inc	3	gas	—	—	7000	Crdwll
Signal Oilfield Service	9	dsl	150	—	6000	Crdwll RL
Barton County						
Sage Drlg Co Inc	1	LPG	150	5000	5000	B Erie
Butler County						
Carter Drlg Co	1	LPG	145	3500	6500	Wlkr-Nr S-43
	2	LPG	145	2000	4500	Wlkr-Nr C-33
Rex & Morris Drlg Co	1	dsl	—	3500	4500	B Erie 36-L
J H Wagner Drlg Co	2	gas-LPG	145	3500	4500	B Erie 36 L
Chautauqua County						
Bennett Drlg Co	3	LPG	—	2750	3250	B Erie 28-L
Cowley County						
SeRoBee Drlg Co Inc	1	btne	—	4000	—	Crdwll RL
J H Wagner Drlg Co	3	gas-LPG	145	3500	4500	B Erie 36-L
Earl F Wakefield	2	gas-btne	220	5500	9500	B Erie 48-L
Edwards County						
L C Smitherman Drlg Co	6	btne	—	7500	—	Crdwll RL
Elk County						
Veeder Supply & Dev Co	BE 2	dsl	120	3500	4500	B Erie
Ellis County						
Signal Oilfield Service	1	dsl	200	—	6000	Crdwll RL
K Smith Cable Tools	1	gas-prop	145	3000	5000	Wlkr-Nr
Finney County						
Graham-Michaelis Drlg Co	4	dsl	175	—	8000	Crdwll RL
Graham County						
Bill's Drlg Serv	1	dsl	—	4500	4500	Crdwll Spdr RI
Harvey County						
SeRoBee Drlg Co Inc	2	btne	—	4000	—	Crdwll RL
Kingman County						
Mobile Drlg Co	2	gas	100	—	5000	Crdwll
	3	gas	100	—	5500	Crdwll
Russell County						
Shields Oil Producers	2	dsl	160	3500	7000	B Erie 48-L
	3	dsl	160	3500	7000	Crdwll RL
Earl F Wakefield	1	gas-btne	220	5500	9500	B Erie 48-L
Sedgwick County						
Carter Drlg Co	3	LPG	160	2000	4500	Wlsn Mogul
Mobile Drlg Co	1	gas	75	—	3600	Crdwll
Sherman County						
Signal Oilfield Serv	7	gas	145	—	5000	Wlkr-Nr C-34
Stafford County						
Mobile Drlg Co	5	gas	100	1000	5500	Crdwll
Stanton County						
Graham-Michaelis Drlg Co	1	dsl	175	3000	8000	Crdwll
Trego County						
Mobile Drlg Co	4	gas	100	100	5500	Crdwll
KENTUCKY						
Henderson County						
Shulman Bros	1	gas-gaso	—	4000	—	Crdwll H
MICHIGAN						
Arenac County						
Goll Graves & Mechling Inc	1	LPG	—	5000	6000	B Erie 36-L
Bay County						
Muskegon Dev Co	—	dsl	150	5000	5000	Natl
Gladwin County						
Muskegon Dev Co	—	dsl	150	5000	5000	Natl
Hillsdale County						
Gordon Drlg Co	5	gas-LPG	150	4000	5000	Crdwll H
McClure Oil Co	4	gas	145	4500	4500	B Erie 36-L
Kent County						
McClure Oil Co	3	gas	145	5000	5000	B Erie 36-L
Montcalm County						
McClure Oil Co	1	gas	145	5000	5000	B Erie 36-L
	2	gas	145	5000	5000	B Erie 36-L
Oceana County						
Bernhardt Drlg Co	1	btne	175	4000	—	B Erie 36
Muskegon Dev Co	—	dsl	150	5000	5000	Natl
Ogemaw County						
Muskegon Dev Co	—	dsl	150	5000	5000	Natl
St Clair County						
Goll Graves & Mechling Inc	2	LPG	—	5000	6000	B Erie 36-L
Saginaw County						
Bernhardt Drlg Co	2	btne-gas	175	4000	—	B Erie 36
Muskegon Dev Co	—	LPG	165	6000	6000	Wlkr-Nr S-33
MONTANA						
Fallon County						
Signal Oilfield Service	10	dsl	225		12,000	Frnks Clpr
	14	dsl	215	—	8000	Frnks Rocket
Glacier County						
Oien Oil Corp	1	dsl	150	3000	5000	B Erie 36-L
	2	gas-LPG	150	3000	5000	B Erie 36-L
Liberty County						
B & B Drlg Co (Montana)	1	gas	145	3500	—	B Erie 36-L
Pondera County						
J W Lawrence	1	gas-gaso	125	3500	—	Natl
	2	gas-gaso	175	5000	—	B Erie
NEBRASKA						
Banner County						
Eatmon Drlg Co	1	prop	—	—	8000	Crdwll RL
Cheyenne County						
Signal Oilfield Serv	11	dsl	—	—	8000	Crdwll RL
Kimball County						
Eatmon Drlg Co	2	prop	—	—	8000	Crdwll RL
	3	prop	—	—	6000	Wlkr-Nr
Signal Oilfield Serv	2	gas-btne	215	—	8000	Frnk Rocket
Richardson County						
Nemaha Oil Co	1 (wo)	gas	150	—	4500	Wichtex C-60
NEW MEXICO						
Eddy County						
Aldridge & Stroud Inc	2	LPG	525	2500	5000	B Erie 36-L
Carper Drlg Co Inc	5-C	gas-LPG	125	4000	4500	B Erie 36-L
Kersey & Co	1	gas-gaso	185	5000	5000	Natl 3
	2	gas-gaso	120	3000	3500	Wich Spddr 55
	3	gas-gaso	120	4000	4500	Wich Spddr 61
	4	gas-gaso	120	4000	4500	Natl 3
Needham Drlg Co	1	LPG	180	5000	—	Wich Spdr 66
	2	LPG	180	5000	—	Wich Spdr 66

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
S P Yates Drlg Co	3	LPG	150	3500	—	Wichita 55
	4	LPG	130	3000	—	Ft Wrth Spr J
	5	LPG	180	6000	—	Ft Wrth Jumbo J
	6	LPG	180	6000	—	Ft Wrth Jumbo J
Lea County						
Carper Drlg Co Inc	C-C	gas-LPG	145	6000	7000	Wlkr-Nr S-55
Art West Drlg Co	3	gas	145	—	6000	Crdwll RL
	7	gas	145	—	8000	Crdwll RL
Western Drlg Co Inc	10	btne	185	—	—	B Erie 48-L
San Juan County						
Signal Oilfield Service	12	dsl	—	—	8000	Crdwll RL
OHIO						
Hocking County						
R A Cooper Drlg Co	1	gas	—	4000	4000	Natl 12
Wood County						
H J Lininger	2	dsl	175	3500	—	L C Moore
Wyandot County						
H J Lininger	1	gas-gaso	78	2500	—	Beth Cyclone
	3	gas-gaso	65	1800	—	Beth Cyclone
OKLAHOMA						
Beaver County						
Chambless-Rosen Drlg Co	2	gas-btne	145	—	10,000	Crdwll RL
Dunnam & Wyant Drlg Co	1	LPG	145	—	8000	Crdwll RL
Caddo County						
G H Ray Well Serv Co	1	gaso-gas	—	12,000	—	Wisn Master
	5	gaso-gas	—	12,000	—	Crdwll RL
	6	gaso-gas	—	12,000	—	Crdwll S-60
	7	gaso-gas	—	4500	—	Wilson
	8	gaso-gas	—	12,000	—	Crdwll
Creek County						
Acacia Drlg Co	1	btne	175	4500	4500	B Erie 36-L
Bennett Drlg Co	2	LPG	—	3500	4000	Star 45
	9	LPG	—	3500	4500	Wlkr Nr 34
4-J Drlg and Well Serv Co	1	gaso	—	—	4500	B Erie 36-L
	2	gaso	—	—	3500	Wlkr-Neor
M L (Mike) Marrs Drlg Co	1	LPG	145	3500	4500	B Erie 36-L
	2	LPG	145	3500	5000	B Erie 36-L
	4	LPG	145	3500	5000	B Erie 36-L
Garfield County						
Chambless-Rosen Drlg Co	4	gas-btne	145	—	10,000	Crdwll RL
Hayward Drlg Co	2	gas	145	4000	—	Brwstr
Grant County						
Sooner Drlg Co	4	LPG	145	5000	7500	Wlkr-Nr
Kay County						
Dave Morgan Drlg Co	—	LPG-gas	145	—	6500	Crdwll RL
Kiowa County						
Ellis Drlg Corp	2	btne	45	2400	3000	B Erie 28-L
Lincoln County						
Bodard Drlg Co	2	gas	225	7000	7000	Wlkr-Nr C-34
Seiboldt Drlg Co	1	gas-btne	165	7000	9000	Wlkr-Nr
Noble County						
Chambless-Rosen Drlg Co	3	gas-btne	145	—	10,000	Crdwll RL
Sooner Drlg Co	2	LPG	145	5000	7500	Wlkr-Nr
Nowata County						
Bennett Drlg Co	6	LPG	—	1750	2250	B Erie 24-L
	10	LPG	—	2000	2500	B Erie 60-L
Okfuskee County						
Floyd R Hyer	1	gas-gaso-btne	60	2250	2750	Star Spddr K
	—	—	—	2200	—	Star Spddr K
Skinner & McDougal Drlg Co	2	gaso-btne	145	4000	5500	Wlkr-Nr
	3	gaso-btne	145	4000	5500	Cardwell
Okmulgee County						
Acacia Drlg Co	2	btne	175	4500	4500	B Erie 36-L
	3	btne	175	4500	4500	B Erie 36-L
Gold-Mar Drlg Co	1	LPG	125	2500	3500	Wich Spddr 25
Ralph G Ladd	1	gas-gaso	65	1750	2500	Star Spddr K
Smallwood & Son	2	btne	—	3500	5600	B Erie 36-L
Osage County						
Bennett Drlg Co	8	LPG	—	2750	3250	B Erie 28-L
W C Holt Drlg Co	1	gas	130	3000	4000	Wlkr-Nr
	2	gas	140	3500	4000	Wlkr-Nr
R L Horn & Sons Drlg Co	1	dsl	60	1600	2000	Star 72
Signal Oilfield Service	3	gas	145	—	6000	Crdwll RL
	8	gas	145	—	5000	Wlkr-Nr C-34
Tolson Drlg Co	1	LPG	145	4000	5000	Wlkr-Nr S-33
Pawnee County						
M L (Mike) Marrs Drlg Co	3	LPG	145	3500	5000	B Erie 36-L
Payne County						
Foster Drlg Co Inc	1	prop	135	—	3500	Cooper
	3	prop	135	—	4000	Wlkr-Nr
Skinner & McDougal Drlg Co	1	gaso-btne	145	4000	6500	Cardwell

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Pontotoc County						
J G Cantrell Drlg Co	1	gaso	25	—	1800	Allis Chmrs Spddr
Troup & Suttles Inc	1	gas-gaso	145	—	9000	Wlkr-Nr 33
Tulsa County						
J M Corbett	1	gas	—	5000	6500	Ft Wrth
J M C Drlg Interests	2	gas	—	1500	—	Keystone
Alfred Meier Drlg Co	—	btne	130	2500	3500	B Erie
Mora Drlg Co	1	dsl	250	5000	—	Wisn Mogul
	4	gas	300	7000	—	Wisn Giant
	6	dsl	250	5000	—	Wisn Mogul
	7	gas	200	3500	—	Natl T-12
Triple S Drlg Co	—	btne	120	2500	3500	B Erie 60-L
Washington County						
Bennett Drlg Co	5	LPG	—	2750	3250	B Erie 28-L
Delaware Drlg Co	2	LPG	110	1800	2500	Wichtex 15
R W Uhl	1	gas-gaso	—	2500	3000	B Erie 28-L
PENNSYLVANIA						
Berks County						
C S Garber & Sons Inc	31	gas-gaso	32	1500	—	—
	32	gas-gaso	32	1500	—	—
Chester County						
C S Garber & Sons Inc	34	gas-gaso	32	1500	—	—
Clearfield County						
Fairman Drlg Co	2	dsl	225	7500	8000	B Erie Spdr 48-L
	3	gas	225	7500	8000	B Erie Spdr 48-L
Indiana County						
Fairman Drlg Co	4	gas	225	7500	8000	B Erie Spdr 48-L
	5	dsl	170	5000	6000	B Erie Spdr 36-L
Lehigh County						
C S Garber & Sons Inc	29	gas-gaso	32	1500	—	—
	30	gas-gaso	32	1500	—	—
Montgomery County						
C S Garber & Sons Inc	33	gas-gaso	32	1500	—	—
Potter County						
Fairman Drlg Co	1	dsl	225	7500	8000	B Erie Spdr 48-L
TEXAS						
Andrews County						
McQueen & Stout Drlg Co	16	LPG	185	5000	5000	Crdwll RL
Brown County						
Joe W Miller	1	btne	74	1000	1000	Ft Wrth Spr C
Carson County						
J R McGill	1	gas-gaso	—	—	—	B Erie
	2	gas-gaso	—	—	—	B Erie
Clay County						
Lin-Mour Drlg Co	2	gas	125	—	6500	Wlkr-Nr C-34
Cochran County						
Western Drlg Co Inc	3	btne	145	—	—	B Erie 36-L
	4	btne	185	—	—	B Erie 48-L
Coleman County						
W H McGarr Ind	2	gas-LPG	100	2500	2500	Ft Wrth Spdr D
Cooke County						
Chas E Hipp Co	16	btne	145	4000	5000	B Erie 36-L
	19	btne	225	6000	9000	B Erie 48-L
Russell & Russell Drlg & Prod Co	1	gaso	80	2500	2500	Ft Wrth Spr H
Crane County						
Aldridge & Stroud Inc	10	—	145	4000	4000	B Erie 60-L
Crockett County						
Aldridge & Stroud Inc	4	LPG	—	2500	2500	Ft Wrth D
Culberson County						
Aldridge & Stroud Inc	8	LPG	145	4500	4500	Wichita 61
	9	LPG	—	6000	6000	Ft Wrth J
Ford Chapman Drlg Contr	2	LPG	225	7000	8500	B Erie 48-L
J E B Drlg Co	1	gas-LPG	200	5200	6700	Wlkr-Nr S-33
Ray Smith Drlg Co	S-32	gas-LPG	140	3000	4000	Wlkr-Nr S-32
	S-33	gas-LPG	140	5000	6000	Wlkr-Nr S-33
	S-43	gas-LPG	140	3000	4000	Wlkr-Nr S-43
The Theiss Drlg Co	3	gaso	100	3000	4000	Wlkr-Nr S-32
Eastland County						
Kent & Preston	2	btne	120	4000	4000	Ft Wrth Jumbo
Ector County						
Eastland Drlg Co	6	gas	125	4500	6000	B Erie
McQueen & Stout Drlg Co	18	LPG	145	5000	—	Natl 3
Art West Drlg Co	5	gas	185	—	8000	Crdwll RL
	9	gas	185	—	9000	Wisn Gnt
	10	dsl	125	—	8000	Crdwll RL
Gray County						
C F Hills Drlg Co	3	gas-btne	145	6000	7800	Wlkr-Nr C-34
Hockley County						
Western Drlg Co Inc	8	btne	185	—	—	B Erie 48-L
Howard County						
C D Turner Drlg Co	1	btne	145	3500	8000	Wlkr-Nr C-37

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Hutchinson County						
Moran Bros Inc	3	gas-LPG	175	4500	7000	B Erie 36-L
Robinson Bros Drlg Co	1	gas	200	4500	5000	B Erie 48-L
Jack County						
Oney Drlg Co	3	gas	210	6500	—	Wichita
Kinney County						
W H McGarr Ind	1	gas-LPG	120	4500	4500	Wich 61
Maverick County						
Errol Elkins Drlg Co	2	LPG	150	5000	6500	B Erie 36
	2	LPG	150	5000	6500	B Erie 36-L
Louis Pitcock Drlg Co	3	dsl	225	6000	7000	Wich 66
McCulloch County						
Kent & Preston	1	dsl	160	6000	—	Ft Wrth J-37
Midland County						
E H Adams Drlg Co	1	gas-btne	150	4000	8000	Crdwll
Chas E Hipp Co	11	btne	225	6000	9000	B Erie 48-L
Russell & O'Donnell Inc	1	LPG-gas-gaso	225	8000	10,000	B Erie 48-L
	2	LPG-gas-gaso	225	8000	10,000	B Erie 48-L
Mitchell County						
Ellis Drlg Corp	1	btne	48	2400	3000	B Erie 28-L
The Theiss Drlg Co	4	gaso	100	3500	4500	Wlkr-Nr S-43
	5	btne	100	3000	4000	Wlkr-Nr S-32
Ochiltree County						
Graham-Michaelis Drlg Co	2	dsl	175	3000	8000	Crdwll
Palo Pinto County						
E & H Drlg Co	1	gas-btne	550	7500	10,000	M-CSCO U-15
Oney Drlg Co	1	gas	165	5500	—	Wichita
Pecos County						
Aldridge & Stroud Inc	11	—	145	4030	4000	Wichita 55
Reagan County						
Wilbanks & Rutter Drlg Co	2	gas	—	—	—	—
Reeves County						
Ford Chapman Drlg Contr	1	LPG	120	4500	5500	B Erie 36-L
Scurry County						
Ellis Drlg Corp	3	btne	60	4000	5000	B Erie 36-L
Shackelford County						
J Conley Miles Drlg Co	1	btne	114	2500	3500	Ft Wrth D
W H Varner Drlg Co	1	gaso	75	1500	—	B Erie 22-W
	1	btne	150	—	—	Wisn Spr
Sherman County						
Graham-Michaelis Drlg Co	3	dsl	150	3500	6000	B Erie 36
Sutton County						
Saunders Drlg Inc	1	LPG	70	2500	3000	B Erie 28-L
Wesley C Young Drlg Co	1	LPG	145	3500	4500	B Erie 36-L
	2	LPG	145	3500	4500	B Erie 36-L
	3	LPG	100	2800	3500	B Erie 28-L
	4	LPG	100	2800	3500	B Erie 28-L
	5	LPG	400	1500	2000	B Erie 22-W

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Taylor County						
West Central Drlg Co	2	gas-gaso	—	—	—	Ft Wrth J
Upton County						
Aldridge & Stroud Inc	1	LPG	140	4000	5000	B Erie 36-L
McQueen & Stout Drlg Co	20	LPG	185	5000	5000	Crdwll RL
Ward County						
Aldridge & Stroud Inc	5	LPG	145	—	8500	Crdwll RL
	7	LPG	145	—	8500	Crdwll RL
Bolin Oil Co & D H Bolin	8	gas	145	4500	—	Wlkr-Nr S-45
Hissom Drlg Co	5	gas	180	7500	10,000	Crdwll RL
C C Pollard	—	dsl	150	5000	6000	Wich 66 Spdr
	—	gas	150	4000	5000	Wich 61 Spdr
Art West Drlg Co	36	gas	145	—	8000	Crdwll RL
	8	gas	145	—	8000	Crdwll RL
Wheeler County						
C H Hills Drlg Co	2	gas-btne	145	5000	9000	Wlkr-Nr S-33
Wichita County						
King Edwards (Edwards Drlg Co)	11	btne	—	—	—	Wlkr-Nr Spdr
Lin-Mour Drlg Co	3	btne	100	5000	—	Wlkr-Nr C-33
Ramey Well Service	1	LPG	140	—	8000	Wichtex E-75
	2	LPG	140	—	8000	Wichtex E-75
Winkler County						
Donnell Drlg Co	1	gas-btne	—	5000	5000	Wichita 61
	2	gas-btne	—	5000	5000	Wichita 61
	3	gas-btne	—	5000	5000	Wichita 55
Yoakum County						
Western Drlg Co Inc	2	btne	145	—	—	B Erie 36-L
Young County						
E & H Drlg Co	2	gas-btne	225	4500	6000	M-CSCO U-34
Chas E Hipp Co	12	btne	145	4000	5000	B Erie 36-L
	15	btne	145	4000	5000	B Erie 36-L
	17	btne	225	6000	9000	B Erie 48-L
	18	btne	225	6000	9000	B Erie 48-L
Oney Drlg Co	2	gas	145	5500	—	Wichita
Stephens Oil & Gas Corp	11	gas	145	—	7000	Wlkr-Nr C-34
UTAH						
San Juan County						
Signal Oilfield Service	6	gas-btne	200	—	10,000	Frnks
Uintah County						
Charles M Jameson	1	gas-gaso	—	3500	—	B Erie 36-L
WEST VIRGINIA						
Logan County						
Allen Drlg Co	2	gas	145	5000	6000	B Erie Spdr 36-L
	7	gas	175	3500	5000	Natl Mach 2
Mingo County						
Allen Drlg Co	1	gas	128	5000	6000	B Erie Spdr 36-L
Nicholas County						
Allen Drlg Co	3	gas	128	5000	6000	B Erie Spdr 36-L

CANADIAN DRILLING CONTRACTORS

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

Able Drlg Co Three Hills Alberta Canada
Arrow Drlg Co 201 Oil Exchange Bldg Calgary Alberta Canada
Peter Bawden Drlg Ltd 810-A First St W Calgary Alberta Canada
Big Horn Drlg Ltd 6530 100th St Edmonton Alberta Canada
Border Drlg Co Ltd Box 40 Lloydminster Alberta Canada
Brinkerhoff Drlg Co Ltd 1001 Mobil Oil Bldg Calgary Alberta Can
Brown Drlg Ltd 10509 81st Ave Edmonton Alberta Canada
Cactus Drlg Corp Ltd Box 853 Calgary Alberta Canada
Can American Drlg Ltd 320 Seventh Ave W Calgary Alberta Can
Can-Tex Drlg Co Ltd 239 Sixth Ave W Calgary Alberta Canada
Cascade Drlg Co Ltd 330 Ninth Ave W Calgary Alberta Canada
Central Leduc Drlg Co Ltd 224 Ninth Ave W Calgary Alberta Can
Commonwealth Drlg Co Ltd 122 Eighth Ave W Calgary Alberta Can
Coralta Drlg Ltd Box 4104 Edmonton Alberta Canada
Dallas Drlg Co Ltd 1208 First Natl Bk Bldg Dallas Tex
Devon Drlg Co Ltd 703 Fifth St W Calgary Alberta Canada
Double "A" Drlg Co Ltd 709 Eighth Ave W Calgary Alberta Can
Duke Drlg Co Ltd 239 Eighth Ave W Calgary Alberta Canada
Eakle & Holder Drlg Co 116 Mulberry St Evansville Ind
General Petr of Canada Ltd 224 Ninth Ave W Calgary Alberta
Gustavson Drlg Co Ltd 203 Empire Bldg Calgary Alberta Canada
Guthrie McLaren Drlg Ltd 9916 109 St Edmonton Alberta Canada
Hewgley Drlg Co 704 Wilco Bldg Midland Tex
Hi-Tower Drlg Co Ltd 400 Lancaster Bldg Calgary Alberta Canada

Atlantic Refining Personnel Teach PE Course at Texas

Seventeen executives, engineers and research men from the Atlantic Refining Company will present lectures on current research, operational applications and production problems in a unique lecture seminar at the University of Texas this fall.

Approximately 200 petroleum engineering students are expected to enroll in the lectures, entitled "Frontiers in Petroleum Engineering." Dr. Paul D. Torrey, university special lecturer and seminar organizer describes the course as an "unusual example of industrial cooperation in the training of engineering talent."

Topics

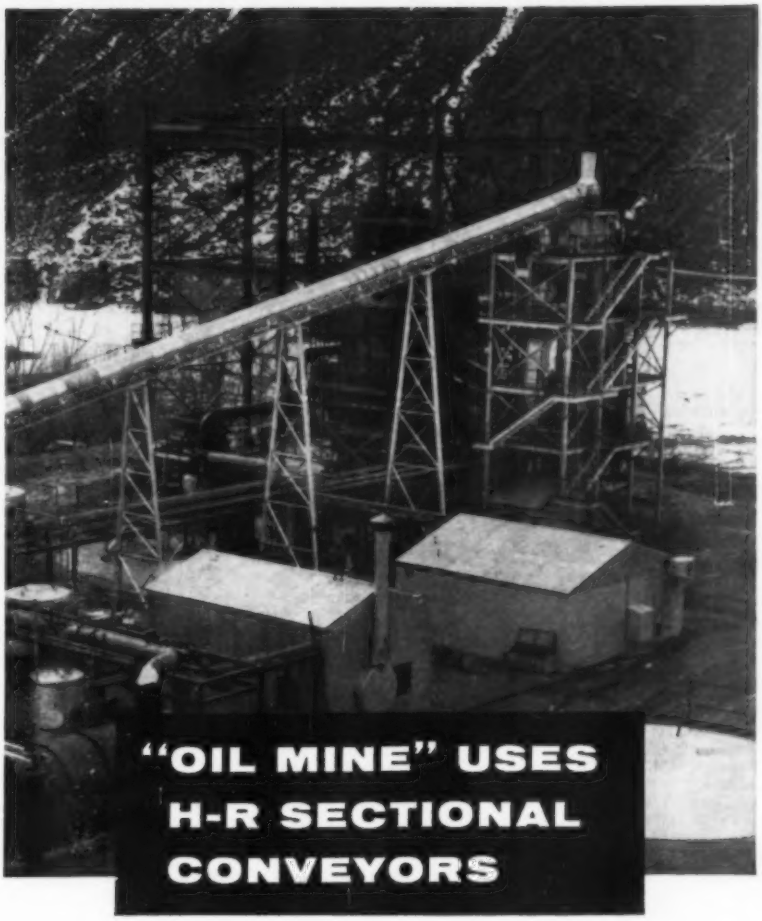
The lecturers, representing years of industrial experience, will cover such topics as the future of offshore drilling, the influence of automation and computers on the oil industry, possible new methods of secondary oil recovery, and ways to conquer the multi-million dollar corrosion problem.

Vern E. Stepp, Atlantic's chief petroleum engineer and seminar coordinator, said the lecturers are engineers, executives, consultants, department heads — men who are putting into practice the concepts which the petroleum engineer obtains at the University, men who are directly confronted with the problems of the petroleum industry.

Stepp opened the lecture series in September. J. B. Harrison, Texas-Ex from Houston who is Atlantic's offshore operations superintendent, will also speak on "Problems in Offshore Drilling."

Other lecturers are from Atlantic's Dallas office, except D. R. Patterson, district production engineer from Corpus Christi, who will speak October 20 on "Applications of Automation — Oil and Gas Production Operations."

Dallas speakers will include John E. Garrett, Jr., Alvin J. Pearson, W. C. Pritchett, S. H. Davis, J. E. Lloyd, Henry Stiff, Jr., Ben H. Caudle, Henry Lewelling, Monte Kaplan, W. F. Kieschnick, C. A. Hutchinson, W. L. Bowser, R. E. Fields, and Paul W. Stade.



Oil carried by belt conveyors is one unique aspect of this experimental oil processing plant built in Colorado for the Union Oil Company of California by Stearns-Roger Manufacturing Company of Denver. Hewitt-Robins sectional belt conveyors are used to carry oil-bearing shale through crushing, screening, storage, and final extraction in an operation which may unlock reserves of a trillion barrels of oil. Because of standard design and interchangeable components, these H-R factory-built sectional conveyors are easily lengthened or relocated to give flexibility to the system.

These pre-engineered conveyors are designed to handle bulk materials from wood chips to lead ore at capacities up to 1000 TPH and speeds as high as 650 FPM. They are easily assembled in the field by your own men.

For information or service, contact your local H-R representative or Hewitt-Robins, Stamford, Conn.

HR HEWITT-ROBINS

CONVEYOR BELTING AND IDLERS . . . POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE . . . VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

H-R Product Manufacturing Plants in Buffalo, N. Y. • Chicago, Ill. • King of Prussia, Pa. • Passaic, N. J. Amsterdam, Holland • Johannesburg, South Africa • London, England • Montreal, Canada • Paris, France

Hunter Drlg Ltd 602 Seventh Ave W Calgary Alberta Canada
Jennings Drlg Co (Alta) Ltd 133 Sixth Ave SE Calgary Alberta Can
Kenyons Drlg Ser Co Ltd 10439 82nd Ave Edmonton Alberta Can
L & J Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Lohmann-Johnson Drlg Co Ltd 208 Bamlett Bldg Calgary A Can
M W Drlg & Ser Ltd Suite A 328 A 8th Ave W Calgary Alberta Can
Moore Drlg Co Ltd 502 Empire Bldg Calgary Alberta Canada
Mortenson Drlg Co 8706 83rd Ave Edmonton Alberta Canada
Parker Drlg Co of Canada Ltd 409 8th Ave W Calgary Alberta
Patterson & Culver Box 92 Dunnville Ontario Canada
Pennant Drlg Co Ltd 108-A 8th Ave W Calgary Alberta Canada
Petrolia Drlg Co Ltd 2412 4th St SW Calgary Alberta Canada
Precision Drlg Co Ltd 1134 8th Ave W Calgary Alberta Canada
Reading & Bates Drlg Co Ltd Royal Bk Bldg Calgary Alberta Can
Regent Drlg Co Ltd Box 421 Edmonton Alberta Canada
Rine Drlg Co of Canada Ltd 534 8th Ave SW Calgary Alberta Can
Ryland Drlg Ltd 10318 82nd Ave Edmonton Alberta Canada
S & T Drlg Co Ltd 10852 82nd St Edmonton Alberta Canada
Trident Drlg Co Ltd 830 Eighth St W Calgary Alberta Canada
Trinity Canadian Drlg Co 1001 F R Webster Bldg
237 Seventh Ave W Calgary Alberta Canada
Union Rotary Drlrs (Canada) Ltd 155 Wellington St
Sarnia Ontario Canada
Wilrich Drlg Ltd 10584 107th St Edmonton Alberta Canada
Wright & Bruce Ltd Suite A 328 A 8th Ave W Calgary Alberta Can

Canadian Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALBERTA						
Double-A Drlg Co Ltd	2	dsl	800	Ideco H-525	600	8,000
Hewgley Drlg Co	3	dsl	—	Emsco J-750	975	10,000
Alex						
Can-Tex Drlg Co Ltd	7	—	—	"Oilwell" 64B	—	7,500
Alhambra						
Can-Tex Drlg Co Ltd	10	—	—	Emsco J-1100	—	15,000
Bassano						
Can-Tex Drlg Co Ltd	2	—	—	Crdwll RL	—	5,000
	8	—	—	Natl T-25	—	5,500
Bellshill Lake						
Big Horn Drlg Ltd	1	dsl	300	Crdwll S 350	300	5,000
Moore Drlg Co Ltd	6	dsl	400	Emsco 300	300	6,000
Regent Drlg Co Ltd	1	dsl	260	Brwstr N-4	260	6,000
Berland River						
Brinkerhoff Drlg Co Ltd	22	dsl	900	Natl 110	1450	15,000
Big Lake						
Commonwealth Drlg Co Ltd	17	dsl	630	Emsco GB-350	720	6,000
Buck Creek						
Jennings Drlg Co (Alberta) Ltd	3	dsl	250	Beth 55 Twister	300	7,500
Buck Lake						
Reading & Bates Drlg Co Ltd	3	dsl	950	Natl 75	1050	10,000
Calgary						
General Pet of Canada Ltd	10	dsl	1400	Natl 80	1000	12,000
Jennings Drlg Co (Alberta) Ltd	4	dsl	360	M-CSCO U-15	720	9,500
Cardston						
Pennant Drlg Co Ltd	1	dsl	775	M-CSCO U-40	775	11,500
Caroline						
Gen Pet of Canada Ltd	17	dsl	1400	Natl 55	1050	10,000
Cessford						
Precision Drlg Co Ltd	3	dsl	276	Ideco H-30-D	276	5,000
	4	dsl	276	Natl T-20	276	5,000
	9	dsl	276	Brwstr N-4	276	5,000
Chard						
Precision Drlg Co Ltd	2	dsl	276	Ideco H-20-D	184	3,500
	8	dsl	276	Ideco H-30-D	276	4,000
Chigwell						
Commonwealth Drlg Co Ltd	8	dsl	690	Brwstr N-7	600	8,000
Clear Hills						
Can-Tex Drlg Co Ltd	6	—	—	Emsco GA-500	—	8,000
Cochrane						
Commonwealth Drlg Co Ltd	21	dsl	1250	Ideco 7-11	900	10,500
Duke Drlg Co Ltd	5	dsl	700	M-CSCO U-20	1386	13,500
Condor						
Gen Pet of Canada Ltd	16	dsl	1050	Natl 55	1150	10,000
Consort						
Gustavson Drlg Co Ltd	2	dsl	500	Natl T-32	250	6,500
Coronation						
Coralta Drlg Ltd	2	gas	180	Failing 1500	180	1,500/2⅛"
Cynthia						
Ryland Drlg Ltd	2	dsl	670	Natl 50	690	7,500
	4	dsl	450	Emsco 350	475	7,000
Didsbury						
Lohmann-Johnson Drlg Co Ltd	1	dsl	550	"Oilwell" 66	550	7,500
Pennant Drlg Co Ltd	2	dsl	1155	Brwstr N-7	755	8,500
	5	dsl	900	M-CSCO U-40	900	11,500
Donalda						
Trident Drlg Co Ltd	13	dsl	—	"Oilwell" 66	530	7,500
Drayton Valley						
Cascade Drlg Co Ltd	16	dsl	250	M-CSCO U-34	250	4,500
Commonwealth Drlg Co Ltd	16	dsl	800	Emsco GB-350	720	7,000
Moore Drlg Co Ltd	8	dsl	640	Beth S-55	640	7,500
Petrolia Drlg Co Ltd	7	dsl	330	Natl 50	330	7,500
	10	dsl	300	M-CSCO U-34	300	5,400
S & T Drlg Co Ltd	1	dsl	520	Natl 50-A	520	8,000
	2	dsl	440	Natl T-32	270	6,000
Eckville						
Lohmann-Johnson Drlg Co Ltd	2	dsl	218	M-CSCO U-15	500	8,500
Edmonton						
Big Horn Drlg Ltd	2	dsl	250	Crdwll L	180	3,500
Commonwealth Drlg Co Ltd	3	dsl	620	Natl 50	600	6,500
	23	dsl	905	Emsco GC-500	800	9,500
Coralta Drlg Ltd	1	gas	180	Failing 1500	180	1,500/2⅛"
Kenyon's Drlg & Serv Ltd	11	dsl	—	Crdwll 151	—	5,000/3½"
Mortenson Drlg Co	2	gaso	110	Failing CFD1	110	1,000
Regent Drlg Co Ltd	3	dsl	720	Brwstr N-55	520	8,000
Edson						
Brinkerhoff Drlg Co Ltd	21	dsl	850	Emsco GB-800	1269	13,500
Trident Drlg Co Ltd	8	dsl	—	"Oilwell" 96	1680	15,500
Forest Lawn						
Trident Drlg Co Ltd	9	dsl	—	"Oilwell" 78	795	10,500
Fox Creek						
Arrow Drlg Co	26	dsl	975	Emsco GB-800	1200	13,000
Can-Tex Drlg Co Ltd	3	—	—	Emsco GB-800	—	12,000
Petrolia Drlg Co Ltd	11	dsl	1035	M-CSCO U-40	1005	12,000
Garrington						
Gen Pet of Canada Ltd	19	dsl	435	Natl T-32	175	5,500
Gilby						
General Pet of Canada Ltd	3	dsl	425	Natl 50-A	650	7,500
Girouxville						
Gustavson Drlg Co Ltd	4	dsl	850	Natl 55	850	10,000
Gleichen						
Moore Drlg Co Ltd	10	dsl	640	Emsco 350	640	6,500
Grande Prairie						
Duke Drlg Co Ltd	8	dsl	500	M-CSCO U-40	670	10,000
Gen Pet of Canada Ltd	5	dsl	800	Natl 80-B	1000	12,000
Parker Drlg Co of Canada Ltd	4	dsl	800	"Oilwell" 76	1100	12,500
	7	dsl	600	Natl 55	670	9,000
Trident Drlg Co Ltd	10	dsl	—	Emsco GB-350	450	7,000
	12	dsl	—	M-CSCO U-15	530	7,500
Greenecourt						
Hi-Tower Drlg Co Ltd	8	dsl	570	M-CSCO U-15	600	8,000
Harmatton						
Commonwealth Drlg Co Ltd	9	dsl	1020	Ideco 700	940	10,000
	28	dsl	920	Natl 55	1000	10,000
Heart River						
Guthrie McLaren Drlg Ltd	1	dsl	300	"Oilwell" T-52	350	7,000
Hinton						
Pennant Drlg Co Ltd	6	dsl	1350	M-CSCO U-40	1200	11,500
Hussar						
Hunter Drlg Ltd	2	dsl	900	Crdwll J-700	1150	12,000
Innisfail						
Brinkerhoff Drlg Co Ltd	1	dsl	625	Emsco GC-500	846	10,000
Can-Tex Drlg Co Ltd	5	—	—	"Oilwell" 66	—	8,000
Gen Pet of Canada Ltd	11	dsl	1400	Natl 80-B	1150	12,000
Hi-Tower Drlg Co Ltd	6	dsl	755	"Oilwell" 76	800	12,000
	10	dsl	755	"Oilwell" 76	800	12,000
Moore Drlg Co Ltd	1	dsl	1000	M-CSCO U-40	1000	10,000
Parker Drlg Co of Canada Ltd	1	dsl	615	"Oilwell" 76	750	11,000
	3	dsl	765	"Oilwell" 76	1005	12,000
Regent Drlg Co Ltd	6	dsl	750	Brwstr N-75	780	10,000
S & T Drlg Co Ltd	3	dsl	900	Natl 55	900	9,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Joffre						
Regent Drlg Co Ltd	2	dsl	520	Brwstr N-55	520	8,000
Joseph Lake						
Big Horn Drlg Ltd	3	dsl	300	Crdwll L-350	300	4,500
Kaybob						
Peter Bawden Drlg Ltd	2	dsl	810	Natl 55	810	10,000
Brinkerhoff Drlg Co Ltd	18	dsl	625	Emsco GC-500	846	10,000
Gen Pet of Canada Ltd	18	dsl	1400	Natl 80-B	1150	12,000
Keystone						
Arrow Drlg Co	8	dsl	250	Emsco GB-350	480	7,000
Peter Bawden Drlg Ltd	1	dsl	415	Natl T-32	275	6,000
Brown Drlg Ltd	1	dsl	275	Crdwll S	—	5,000
Commonwealth Drlg Co Ltd	7	dsl	750	Natl 50	530	6,500
Rine Drlg Co of Canada Ltd	2	dsl	590	Brwstr N-55	720	8,500
Ryland Drlg Ltd	1	dsl	600	Emsco 450	640	7,500
Lake McGregor						
Arrow Drlg Co	6	dsl	250	Emsco GB-350	350	7,000
Leduc						
Wilrich Drlg Ltd	4	dsl	220	Failing 2500	220	3,000/3½"
	6	dsl	300	M-CSCO U-34	300	6,000
Lodgepole						
Jennings Drlg Co (Alberta) Ltd	1	dsl	250	Beth C-50	300	7,500
Nampa						
Trident Drlg Co Ltd	14	dsl	—	"Oilwell" 76	795	10,500
Nanton						
Trident Drlg Co Ltd	4	dsl	—	Natl 100	1140	12,000
Normandville						
Gustavson Drlg Co Ltd (Northwestern)	5	dsl	420	Natl T-32	275	6,500
Cascade Drlg Co Ltd	12	dsl	—	Natl 80B	—	14,000
Olds						
Trident Drlg Co Ltd	7	dsl	—	"Oilwell" 76	795	10,500
Peace River						
Moore Drlg Co Ltd	5	dsl	600	M-CSCO U-15	600	7,500
Parker Drlg Co of Canada Ltd	8	dsl	400	Natl 50	500	6,500
	10	dsl	400	Natl 50-A	500	7,000
Regent Drlg Co Ltd	24	dsl	720	Brwstr N-7	520	8,000
Pembina						
Arrow Drlg Co	19	dsl	250	Emsco GB-350	480	7,000
Peter Bawden Drlg Ltd	5	dsl	440	Natl T-32	270	5,500
	8	dsl	300	Natl T-32	300	6,500
Brinkerhoff Drlg Co Ltd	15	dsl	370	Natl 50-A	600	8,500
	16	dsl	370	Emsco GA-350	450	7,500
Brown Drlg Ltd	2	dsl	550	Natl 50	550	7,500
Cactus Drlg Corp Ltd	3	dsl	420	Natl T-32	280	6,000
Cascade Drlg Co Ltd	1	dsl	—	Natl 50	—	6,500
	3	dsl	—	Natl 50	—	6,500
	7	dsl	—	Natl 50-A	—	7,500
	8	dsl	—	Natl 50	—	6,500
	9	dsl	—	Natl T-32	—	5,500
	10	dsl	—	Natl 50	—	6,000
Commonwealth Drlg Co Ltd	10	dsl	550	Ideco H-35D	300	6,500
Duke Drlg Co Ltd	2	dsl	650	Natl 50	650	8,000
Gen Pet of Canada Ltd	14	dsl	350	Crdwll OA	500	6,500
Gustavson Drlg Co Ltd	1	dsl	500	Natl 50	500	7,500
	3	dsl	275	Ideco H-40	300	6,500
Hi-Tower Drlg Co Ltd	4	dsl	350	Natl 50	450	6,500
Parker Drlg Co of Canada Ltd	6	dsl	420	"Oilwell" 52-T	420	6,500
	11	dsl	400	Natl 50	500	6,500
Reading & Bates Drlg Co Ltd	5	dsl	375	Natl 50-A	600	7,000
Regent Drlg Co Ltd	26	dsl	260	Ideco H-40	260	6,000
	28	dsl	500	Natl 50A	520	7,000
	30	dsl	260	Ideco H-40	260	6,000
Trident Drlg Co Ltd	1	dsl	—	"Oilwell" 64B	530	6,000
	3	dsl	—	"Oilwell" 64B	530	6,000
Penhold						
Hi-Tower Drlg Co Ltd	7	dsl	525	"Oilwell" 66	550	8,000
Pincher Creek						
Brinkerhoff Drlg Co Ltd	8	dsl	900	Natl 110	1200	15,000
	17	dsl	850	Emsco A-800	1269	14,000
Commonwealth Drlg Co Ltd	26	dsl	1275	Natl 80B	1410	12,000
Regent Drlg Co Ltd	7	dsl	1200	Natl 125	1500	15,000
Ponoka						
Hi-Tower Drlg Co Ltd	1	dsl	525	"Oilwell" 66	550	8,000
Ram River						
Duke Drlg Co Ltd	6	dsl	850	M-CSCO U-20	1386	13,500
	7	dsl	850	M-CSCO U-20	1386	13,500
Red Deer						
Peter Bawden Drlg Ltd	6	dsl	722	M-CSCO U-36A	722	8,500
Gen Pet of Canada Ltd	4	dsl	500	Natl 50-A	650	7,500
	6	dsl	400	Natl 50-A	500	7,000
Moore Drlg Co Ltd	2	dsl	600	Emsco 450	640	7,000
	7	dsl	960	Beth S-55	640	7,500
	9	dsl	640	Ideco 525	640	7,500
Red Earth						
Commonwealth Drlg Co Ltd	11	dsl	260	Ideco H-40 D	300	5,500
Redwater						
Gen Pet of Canada Ltd	12	dsl	250	Natl T-20	250	4,600
Rimbey						
Reading & Bates Drlg Co Ltd	1	dsl	300	Natl 50-A	700	7,000
Savannah Creek						
Peter Bawden Drlg Ltd	10	dsl	900	Natl 80B	1200	13,500
Scarcee						
Reading & Bates Drlg Co Ltd	4	dsl	950	Natl 80-B	1050	12,000
Sedgewick						
Guthrie McLaren Drlg Ltd	2	dsl	500	"Oilwell" T-52	350	7,500
Simonette River						
Arrow Drlg Co	21	dsl	1250	Emsco J-1250	1400	14,000
Can American Drlg Ltd	3	dsl	750	Natl 80-B	1645	10,000
Smith						
Can-Tex Drlg Co Ltd (Southeastern)	9	—	—	Crdwll OT	—	7,000
Cactus Drlg Corp Ltd	4	dsl	200	Emsco GB-160	200	4,000
Standard						
Hi-Tower Drlg Co Ltd	5	dsl	350	Natl 50	450	5,000
	9	dsl	285	Crdwll D	300	5,000
Steelman						
Regent Drlg Co Ltd	27	dsl	260	Brwstr N-4	260	6,000
Steen River						
Regent Drlg Co Ltd	21	dsl	260	Brwstr N-4	260	9,000/3½"
Stettler						
Parker Drlg Co of Canada Ltd	5	dsl	420	Natl 50	420	7,000
Sturgeon Lake						
Peter Bawden Drlg Ltd	7	dsl	720	Natl 55	720	9,500
Commonwealth Drlg Co Ltd	19	dsl	735	Natl 50-A	790	9,500
Sundre						
Cascade Drlg Co Ltd	14	dsl	—	M-CSCO U-20	—	14,000
Jennings Drlg Co (Alberta) Ltd	2	dsl	250	Beth C-50	300	7,500
Parker Drlg Co of Canada Ltd	9	dsl	765	Natl 125	1005	14,000
Sunnynook						
Commonwealth Drlg Co Ltd	13	dsl	630	Emsco GA-350	720	6,500
Swan Hills						
Can-Tex Drlg Co Ltd	12	—	—	Emsco GB-800	—	12,000
Hi-Tower Drlg Co Ltd	3	dsl	525	"Oilwell" 66	550	8,000
Regent Drlg Co Ltd	9	dsl	750	Brwstr N-75	780	10,000
Thompson Lake						
Peter Bawden Drlg Ltd	12	dsl	250	Natl T-12	225	4,000
Three Hills						
Able Drlg Co	10	gaso	40	Failing 1500	—	1,500/2⅛"
	20	gas	46	Mayhew	—	1,000/2⅛"
Torrington						
Can-Tex Drlg Co Ltd	4	—	—	Crdwll OC	—	8,000
Valleyview						
Parker Drlg Co of Canada Ltd	2	dsl	615	"Oilwell" 76	750	11,000
Vauxhall						
Peter Bawden Drlg Ltd	3	dsl	270	Crdwll S	180	4,500
Vegreville						
Wilrich Drlg Ltd	2	dsl	300	Natl T-12	300	4,000/3½"
Vulcan						
Devon Drlg Co Ltd	3	dsl	700	Emsco GB-500	500	9,500
Wainwright						
Border Drlg Co Ltd	1	dsl	175	Crdwll L	150	3,500
Waterton Lakes						
Commonwealth Drlg Co Ltd	1	dsl	1350	Natl 110	1500	14,000
Whitecourt						
Peter Bawden Drlg Ltd	9	dsl	1000	M-CSCO U-40	1000	12,000
Cascade Drlg Co Ltd	17	dsl	—	Natl 75	—	12,000
Duke Drlg Co Ltd	9	dsl	500	M-CSCO U-15	650	8,500
Parker Drlg Co of Canada Ltd	12	dsl	600	"Oilwell" 66	670	9,000
Pennant Drlg Co Ltd	4	dsl	1000	Crdwll O	650	9,500
Regent Drlg Co Ltd	8	dsl	750	Brwstr N-75	780	10,000
	25	dsl	750	Brwstr N-75	780	10,000
Wimborne						
Gen Pet of Canada Ltd	15	dsl	1400	Natl 55	1050	10,000
Windfall						
Reading & Bates Drlg Co Ltd	6	dsl	800	Natl 80-B	1200	7,000
BRITISH COLUMBIA PROVINCE						
Alcan Highway—Mile—142						
Reading & Bates Drlg Co Ltd	7	dsl	800	Natl 55-A	1200	12,500
Alcan Highway—Mile—143						
Brinkerhoff Drlg Co Ltd	20	dsl	370	Natl 50A	450	8,500
Blueberry						
Arrow Drlg Co	7	dsl	975	Emsco GC-500	900	9,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Dallas Drlg Co Ltd	1	dsl	625	Emsco GB-500	750	9,500
	2	dsl	578	Emsco GB-500	560	8,000
	3	dsl	500	Emsco GB-350	495	7,000
	4	dsl	500	Emsco GB-350	560	7,000
Trinity Canadian Drlg Co	3	dsl	720	Emsco 350	670	7,000
	4	dsl	990	Natl 80-B	990	12,000
Boundary Lake						
Arrow Drlg Co	4	dsl	500	Emsco GB-350	600	7,000
Commonwealth Drlg Co Ltd	15	dsl	800	Brwstr N-7	600	8,000
	20	dsl	1270	Ideco 7-11	900	10,500
Dawson Creek						
Cascade Drlg Co Ltd	4	dsl	—	Natl 50A	—	7,500
Gen Pet of Canada Ltd	7	dsl	1400	Natl 80-B	1300	13,000
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
	5	dsl	1250	Emsco A-800	1150	15,000
	7	dsl	875	Emsco GC-500	720	10,000
Ft St John						
Brinkerhoff Drlg Co Ltd	14	dsl	370	Emsco GB-500	600	8,500
Devon Drlg Co Ltd	1	dsl	700	Emsco GA-500	500	9,500
	2	dsl	300	Emsco GA-350	350	7,500
Reading & Bates Drlg Co Ltd	2	dsl	800	Natl 100	1050	12,000
Regent Drlg Co Ltd	5	dsl	720	Brwstr N-7	520	8,000
Trident Drlg Co Ltd	6	dsl	—	Emsco 500	530	8,000
(Northeastern)						
Cascade Drlg Co Ltd	2	dsl	—	Wisn Rdair	—	9,200
	11	dsl	—	Crdwll D	—	5,500
Pouce Coupe						
Commonwealth Drlg Co Ltd	22	dsl	750	Natl 50	530	6,500
Queen Charlotte Islands						
Cascade Drlg Co Ltd	5	dsl	—	Natl 50A	—	7,500
MANITOBA PROVINCE						
Scallion						
Commonwealth Drlg Co Ltd	18	dsl	260	Ideco H-25D	300	4,500
Virden						
Peter Bawden Drlg Ltd	4	dsl	220	Crdwll RL	205	4,500
NORTHWEST TERRITORY						
Peter Bawden Drlg Ltd	11	dsl	250	Natl T-32	300	5,000
ONTARIO PROVINCE						
Lambton						
Union Rotary Drlg (Can) Ltd	1	gas-LPG	200	Natl 40	180	4,000
	3	gas-LPG	200	Natl 40	180	4,000
Windsor						
Eakle & Holder Drlg Co	4	dsl	300	Natl T-20	300	5,500
SASKATCHEWAN PROVINCE						
Alsask						
Rine Drlg Co of Canada Ltd	1	dsl	300	Brwstr N-45	350	6,500
Arcola						
Moore Drlg Co Ltd	3	dsl	320	Brwstr N-4	190	4,000
Biggar						
General Pet of Canada Ltd	9	dsl	375	Natl T-25	250	5,500
Broadacres						
Commonwealth Drlg Co Ltd	25	dsl	425	M-CSCO U-34D	300	5,500
Carlyle						
Precision Drlg Co Ltd	7	dsl	550	Ideco 525-D	550	7,500
Carnduff						
Can American Drlg Ltd	7	dsl	260	Natl T-20	260	4,500
Can-Tex Drlg Co Ltd	1	—	—	Crdwll RL	—	5,000
General Pet of Canada Ltd	21	dsl	250	Natl T-20	185	4,600
Hunter Drlg Ltd	3	dsl	450	Crdwll	260	6,000
Precision Drlg Co Ltd	6	dsl	276	Ideco H-30-D	276	5,000
Regent Drlg Co Ltd	4	dsl	260	Brwstr N-4	260	6,000
	22	dsl	260	Brwstr N-4	260	6,000
Coleville						
Precision Drlg Co Ltd	1	dsl	276	Ideco H-30-D	276	5,000
Estevan						
Commonwealth Drlg Co Ltd	2	dsl	550	Natl 50	420	6,500
Kenyon's Drlg & Serv Ltd	12	dsl	—	Frnks Comet 658	—	5,000
Regent Drlg Co Ltd	23	dsl	260	Brwstr N-4	260	6,000
Faylerton						
Commonwealth Drlg Co Ltd	5	dsl	260	Emsco GA-250T	310	5,000
Fillmore						
Commonwealth Drlg Co Ltd	12	dsl	260	Natl T-32	300	5,500
Florence						
Can American Drlg Ltd	1	dsl	350	Natl T-32	275	5,000
Frobisher						
Commonwealth Drlg Co Ltd	4	dsl	260	Ideco H-40D	300	6,000
Guernsey						
Can American Drlg Ltd	6	dsl	275	Natl T-12	260	3,000
Halbrite						
Cascade Drlg Co Ltd	6	dsl	—	Natl T-20	—	4,500
Killdeer						
Commonwealth Drlg Co Ltd	6	dsl	690	Ideco M-750	600	7,000
Lloydminster						
Peter Bawden Drlg Ltd	14	dsl	142	Crdwll	100	2,500
Melville						
Brinkerhoff Drlg Co Ltd	12	dsl	200	Natl T-32	300	6,000
Can American Drlg Ltd	4	dsl	260	Natl T-20	260	4,000
Midale						
Commonwealth Drlg Co Ltd	24	dsl	520	Natl 50	600	6,000
General Pet of Canada Ltd	8	dsl	250	Natl T-25	250	5,000
	20	dsl	275	Emsco GB-250T	275	5,000
Regent Drlg Co Ltd	29	dsl	260	Brwstr N-4	260	6,000
Nottingham						
General Pet of Canada Ltd	2	dsl	250	M-CSCO U-34	250	4,800
Oxbow						
Moore Drlg Co Ltd	4	dsl	330	Emsco 300	300	5,000
Rouleau						
Can American Drlg Ltd	2	dsl	650	Natl T-55	975	7,500
(Southeastern)						
Double-A Drlg Co Ltd	1	dsl	340	Ideco H-30	265	4,500
	3	dsl	340	Ideco H-40	265	6,000
Steelman						
General Pet of Canada Ltd	1	dsl	250	Natl 50	525	6,500
Hunter Drlg Ltd	1	dsl	450	Crdwll	260	6,000
Ryland Drlg Ltd	3	dsl	320	Natl T-32	320	6,000
Success						
Commonwealth Drlg Co Ltd	14	dsl	580	Ideco H-40 D	660	5,500
Swift Current						
Precision Drlg Co Ltd	5	dsl	276	Brwstr N-4	276	5,000
	10	dsl	550	Ideco 525-D	550	7,500
	11	dsl	550	Crdwll D	550	6,000
	12	dsl	276	Natl T-20	276	5,000
Viewfield						
Can American Drlg Ltd	5	dsl	375	Natl T-32	320	5,000
Weyburn						
Central Leduc Drlg Co Ltd	1	dsl	500	Natl 50	500	6,500
	2	dsl	285	Crdwll TR 66	245	5,000

Canadian Cable Tools

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALBERTA PROVINCE						
Drayton Valley						
M W Drlg & Serv Ltd	1	dsl	135	—	6000	Crdwll H
	4	gaso	80	—	3000	Crdwll Q
	5	dsl	135	—	6000	Crdwll AH
	7	gaso	80	—	3000	Crdwll Q
	8	dsl	250	—	12,000	Wisn Spr 3B
Medicine Hat						
Wright & Bruce Ltd	10	dsl	135	—	3500	B Erie 28-L
MANITOBA PROVINCE						
Virden						
Wright & Bruce Ltd	9	dsl	135	—	3500	B Erie 28-L
ONTARIO PROVINCE						
Lake Erie (North Shore)						
Patterson & Culver	2	gas	60	1500	2000	B Erie 24-L
	3	gas	60	1500	2000	B Erie 24-L
Norfolk						
Patterson & Culver	1	gas	80	2500	3500	B Erie 28-L
SASKATCHEWAN PROVINCE						
Coleville						
Wright & Bruce Ltd	4	gaso	100	—	3000	B Erie 24-L
	8	dsl	135	—	3500	B Erie 28-L
	14	dsl	135	—	6000	Crdwll AL
Estevan						
Wright & Bruce Ltd	1	gaso	80	—	3000	Crdwll Q
	11	dsl	135	—	6000	Crdwll AH
	12	dsl	135	—	6000	Crdwl AH

SOME CONTRACT RIGS IN FOREIGN SERVICE

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ARGENTINA						
Tierra Del Fuego						
Laughlin-Porter Drlg Co Inc	2	gas	740	M-CSCO U-15	—	7,500
	8	gas	—	Natl 75	700	900
BRITISH HONDURAS						
Kerr-McGee Oil Ind Inc	14	dsl	695	Natl 50	630	9,000
	50	dsl	1000	Natl 55	770	10,000
COLOMBIA						
Drlg & Expl Co Inc	42	dsl	1800	"Oilwell" 96	2000	18,000
El Centro, Santander						
Llano Drlg Co	8	dsl	800	Ideco H-30	300	4,500
DOMINICAN REPUBLIC						
Comet Drlg Co	2	dsl	1000	Natl 75	750	10,000
FRENCH WEST AFRICA						
Ivory Coast						
Laughlin-Porter Drlg Co Inc	5	dsl	1080	Natl 23-9FEB	—	12,000
INDIA						
West Bengal						
Southeastern Asia Drlg Co	26	dsl	1000	Natl 55	825	10,000
IRAN						
Southeastern Asia Drlg Co Bge	23	dsl	1560	"Oilwell" 96	1560	14,000
JORDAN						
Parker Drlg Co	46	gas	—	Natl 75	700	10,000
LIBYA						
Camdrill International Inc	—	dsl	255	Ideco H-30-D	300	4,500
	2	dsl	1000	Natl 110	2400	13,000
PAKISTAN						
Southeastern Asia Drlg Co	24	dsl	1200	"Oilwell" 96	1600	18,000
	27	dsl	1000	Natl 55	825	10,000
SICILY						
Palermo						
Delta Overseas Drlg Co	1	dsl	900	Ansaldo 2000	600	7,000
	2	dsl	260	Ideco H-30	300	4,500
	3	dsl	500	Emsco GB-500	500	8,500
	4	dsl	900	Emsco 800	900	11,000
TURKEY						
Drlg & Expl Co Inc	—	dsl	1250	Natl 80-B	1500	14,000
	40	dsl	700	Emsco GB-500	1050	7,500
Southeastern Asia Drlg Co	Bge 25	dsl	1040	Natl 130	1560	16,000
VENEZUELA						
Santa Fe Drlg Co	23	dsl	300	Ideco H-40	300	6,000
Anzoategui						
Helmerich & Payne Inc	66	dsl	—	Natl 125	—	—
Perforaciones Delta C A	2	dsl	260	Ideco H-40-D	400	6,500
(Caracas Venezuela)	3	dsl	260	Failing 2066	—	1,500
	4	dsl	260	Ideco H-40-D	400	6,500
	5	stm	1200	Emsco UBLS	1690	15,000
	7	dsl	260	Ideco H-30-D	300	4,500
Barinas						
Helmerich & Payne Inc	62	dsl	—	Natl 125	—	—
	67	dsl	—	Natl 110	—	—
Perforaciones Delta C A	10	dsl	260	Crdwll @	450	7,500
(Caracas Venezuela)						
Guarico						
Perforaciones Delta C A	1	dsl	260	Ideco H-40-D	400	6,500
(Caracas Venezuela)						
Monagas						
Helmerich & Payne Inc	61	dsl	—	Natl 125	—	—
	63	stm	—	Natl 34-10	—	—
	64	stm	—	Natl 34-10	—	—
	65	dsl	—	Natl 50-A	—	—
	68	stm	—	Natl 34-10	—	—
Perforaciones Delta C A	Bge 12	dsl	1560	Emsco J-1250	1250	15,000
Zulia						
Perforaciones Delta C A	8	dsl	600	Emsco G-500	500	8,000
(Caracas Venezuela)						
	9	dsl	1000	Emsco GB-800	900	12,000
	11	dsl	130	Natl T-12	120	2,500
	Bge 13	dsl	1040	Emsco J-1250	1250	15,000
	Bge 14	dsl-elec	2000	Emsco ECB	1200	15,000
	Bge 15	dsl-elec	2000	Emsco ECB	1200	15,000
	Bge 16	dsl-elec	2000	Emsco ECB	1200	15,000

U. S. OFFSHORE RIG LOCATOR

Some abbreviations. To provide the greatest amount of information in a compact listing, it is necessary to employ some abbreviations. Manufacturers' names are indicated in the introduction of the RIG LOCATOR. Here is a list of abbreviations employed in the offshore section for operators and operator groups:

Operators

Bahama Cal—Bahama California Oil Company

Blk 27 Associates—Coastal Marine Drilling & Construction Company, Phillips Petroleum Company, Gulf Oil Corporation

CATC—Continental Oil Company, The Atlantic Refining Company, Tidewater Oil Company, and Cities Service Oil Company.

Calco—The California Company.

Humble—Humble Oil & Refining Company.

M-C-N—Magnolia Petroleum Company, Continental Oil Company, and Newmont Oil Company.

Phillips—Phillips Petroleum Company.

Shell—Shell Oil Company.

Sinclair—Sinclair Oil & Gas Company.

Std Cal—Standard Oil Company of California.

Superior—The Superior Oil Company of California.

Texaco—The Texas Company.

IF YOU NEED A WELL SERVICING UNIT . . . for jobs all the way from pulling tubing to well workovers . . . check the NEW feature added to this edition of your RIG LOCATOR. Starting on page R-45 is a list of well servicing contractors, followed by a detailed breakdown of well servicing or pulling units as to type, capacities, and where these units are working. This NEW SECTION includes all principal types of well servicing units in the U. S. and Canada.

CALIFORNIA

SELF-CONTAINED PLATFORMS

Owner's Name	Rig, Barge Name or Number	Operator Drlg For	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Offshore-Submarex Inc	"PCS Exploit"	—	Santa Barbara	—	dsl engine	Howard-Turner	175	175	1,500
	"Labusca"	—	Santa Barbara	—	dsl engine	Howard-Turner	165	165	1,500
	"Sandab V"	—	Santa Barbara	—	dsl engine	Howard-Turner	175	175	1,500
Richfield Oil Corp	"La Ciencia"	*	—	—	dsl engine	Hopper Hoist	165	165	1,500
	"Rincon"	*	—	—	dsl engine	Emsco 160	400	300	4,000
Sun-Marine Drlg Corp (Off-Shore Constr Inc)	"Pacific Driller No. 1"	Std Cal & Humble	Gaviota	90	dsl engine	Natl 110	1500	2500	16,000
Western Offshore Drlg & Expl Co	Rig A	Std Cal	Summerland	100	AC elec	Natl 80-B	1200	1400	—

LOUISIANA

MOBILE DRILLING BARGES

Owner's Name	Rig, Barge Name or Number	Operator Drlg For	Location—Designation	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Barnwell Offshore Inc	"Mister Cap"	Sinclair	Ship Shoal Blk 153	100	dsl-elec	Ideco E-2500	2500	2500	25 000
Coral Drlg Co	"Mr Arthur"	Calco	Grand Isle Blk 26	45	dsl-elec	Brwstr N-12A	1250	2500	20,000+
Delta Marine Drlg Co	Rig 2 "Chris Zeppa"	*	Calcasieu	—	dsl engine	Ideco Bg Gnt	1600	1950	15,000
Dixilyn Drlg Corp	Rig 8 "Julie Ann"	**	S Timbalier Blk 20	105	dsl engine	Natl 1625DE	2490	2490	25,000
Glasscock Drlg Co	Rig 12 "Mr Gus II"	CATC	Eugene Is k 208	97	dsl-elec	Natl 160-E	1950	3900	25,000
Humble Oil & Ref Co	Rig 47	*	—	—	dsl engine	Emsco GB-250TS	260	500	5,000
Kerr-McGee Oil Ind Inc	Rig 47	Phillips	W Cameron Blk 40	36	dsl-elec	Emsco EDA-460	1250	1250	20,000
Louisiana Delta Offshore Corp	Rig 1	Shell	South Pass Blk 27	40	dsl-elec	M-CSCO U-1220	1370	1000	20,000
Ocean Drlg & Expl Co	"Margaret"	Shell	South Pass Blk 27	40	dsl-elec	Emsco EDES	1500	1000	20,000
	"St. Louis"	Shell	South Pass Blk 27	25	dsl-elec	Emsco ECD	1200	1000	15,000
The Offshore Co	Rig 52	Phillips	Eugene Is Blk 129-A	55	dsl engine	Natl 130	1650	1650	20,000
Marine Drlg Inc	Rig 101	*	Terrebonne Bay	45	dsl-elec	Emsco E A	1600	1700	18,000
Rowan Drlg Co Inc	Bge 19	Calco	Bay Marchand Blk 1	—	dsl-elec	M-CSCO U-1220-E	2250	2100	20,000
Southeastern Drlg Corp	Rig 22 Bge 8	Texaco	Marsh Isle (Southwest)	13	dsl engine	Natl	2200	1550	18,000

PLATFORM-TENDER DRILLING UNITS

An-Son Offshore Drlg Co	"Carl B Anderson"	Blk 27 Associates	S Timbalier Blk 27	50	dsl-elec	Emsco EDE	2550	2000	23,000
Delta Marine Drlg Co	Rig 1 "Joseph Zeppa"	*	Calcasieu	—	dsl-elec	Emsco JB-1250	1600	1600	15,000
Dixilyn Drlg Corp	Rig 6	*	Bayou Boeuf	—	dsl engine	Natl 130	1650	2475	17,500
Humble Oil & Ref Co	Rig 46	*	—	—	dsl engine	Emsco J-1400	1000	1000	16,000
	Rig 49	*	—	—	dsl engine	Emsco J-1400	1000	1000	16,000
	Rig 54	Humble	S Timbalier Blk 54	65	dsl engine	Ideco M-2500	1000	1000	16,000
Llano Drlg Co	Rig 6 "Clayton G Dorn"	*	Morgan City	—	dsl engine	"Oilwell" 96	1800	2475	20,000
Magnolia-Continental-Newmont	Rig 48 Bge 4	M-C-N	E Cameron Blk 62	—	dsl engine	Emsco JB-1250	1040	1040	16,000
	Rig 57 Bge 7	M-C-N	Ship Shoal Blk 72	—	dsl engine	Natl 130	1040	1040	16,000
Nicklos Drlg Co	Rig 13 "Ernie Miller"	CATC	West Delta Blk 45	40	dsl engine	Natl 125	1400	—	17,000
Phillips Petroleum Co	Rig 40	*	Bay Marchand	—	dsl engine	Natl 125	1350	1200	16,000
Reading & Bates Offshore Drlg Co	George M Reading	Shell	Eugene Is Blk 175	86	dsl engine	Natl 130	2000	3000	20,000
	"J W Bates"	CATC	Vermilion Blk 123	71	dsl engine	Natl 130	2000	3000	20,000
Rowan Drlg Co Inc	Rig 17	*	Harvey	—	dsl engine	Natl 125	1305	2100	15,000
Salt Dome Prod Co	Rig 10 "Pelican"	*	Morgan City	—	dsl engine	Beth 1013	1500	1500	28,000+
Southeastern Drlg Corp	Rig 12 Bge 9	*	New Orleans	—	dsl engine	"Oilwell" 96	1100	2250	16,000

SELF-CONTAINED PLATFORMS

Brewster-Bartle Drlg Co Inc	Rig 1	CATC	West Delta Blk 45	50	dsl engine	"Oilwell" 96	3300	3300	20,000
Dixilyn Drlg Corp	Rig 7	*	Bayou Boeuf	—	dsl engine	Natl 110	2475	2475	15,000

LOUISIANA — (Continued)

SELF-CONTAINED PLATFORMS — (Continued)

Owner's Name	Rig, Barge Name or Number	Operator Drlg For	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Humble Oil & Ref Co	SM-1	*	—	—	dsl engine	Hopper	300	175	3,500
	Rig 50	Humble	Grand Isle Blk 16	45	dsl engine	M-CSCO U-40	900	450	10,000
Loffland Bros Co	Rig 62	CATC	Grand Isle Blk 47	85	dsl-elec	Natl 34-10	1500	1600	16,000
	Rig 144	Shell	Eugene Is Blk 188	67	dsl engine	M-CSCO U-30	1500	1500	18,000
Nicklos Drlg Co	Rig 19	CATC	West Delta Blk 45	40	dsl engine	Natl 130	2250	2250	20,000
Phillips Petroleum Co	Rig 45	*	Morgan City	—	dsl-elec	Emsco ECC	1250	1250	18,000
Rowan Drlg Co Inc	Rig 11	CATC	Grand Isle Blk 40	—	dsl engine	M-CSCO U-1220	2400	2250	20,000
Shell Oil Co	Marine Rig 10	Shell	W Cameron Blk 192	56	dsl engine	Natl 25	1200	1200	12,500
Shoreline Drlg Co Inc	Rig 7	CATC	Grand Isle Blk 47	92	dsl engine	M-CSCO U-1220	2400	2400	20,000
The Superior Oil Co of Calif	Rig 27	Superior	Vermilion Blk 76	25	dsl engine	Natl 125	900	900	12,500
	Rig 20	*	—	—	dsl engine	Natl 125	900	900	12,500

TEXAS

MOBILE DRILLING BARGES

Nicklos Drlg Co	Rig 20	Texaco	SW Marsh Is SL 340	10	dsl engine	Natl 130	2250	2250	20,000
Zapata Off-Shore Co	Rig 3 "Vinegarroon"	*	—	80	dsl engine	"Oilwell" 96	2080	2150	18,000

PLATFORM-TENDER DRILLING UNITS

Zapata Off-Shore Co	Rig 1 "Nola"	*	—	—	dsl engine	Natl 130	1400	1850	15,000

FOREIGN LOCATIONS

MOBILE DRILLING BARGES

Zapata Off-Shore Co	Rig 2 "Scorpion"	Bahama Cal	Cay Sal Blk B.W.I.	80	dsl engine	"Oilwell" 96	1850	1850	16,000

* Reported Idle September 1, 1958 ** Awaiting Location

U. S. Well Servicing Contractors

Alphabetical Listing

A

A A A Well Serv Co Box 3581 Shreveport La
Adams Prod Serv 2 Monte Vista Dr Bakersfield Calif
C N Adkisson Jr Box 875 McCamey Tex
Albright Well Serv Co Box 1192 Hobbs N M
Allied Well Serv Inc Box 688 South Houston Tex
Bill Atchley Box 8 Seymour Tex
Atlas Well Serv Inc Box 387 Ft Morgan Colo

B

B & B Oil Well Serv Box 6 Oil City La
B & G Well Serv 2011 S Main Winfield Kans
B H B Superior Well Serv Inc Box 5 Denver City Tex
B-J Well Serv Box 92 Abilene Tex
B K Well Serv Box 365 Plainsville Kans
Bailey Well Serv Inc Box 455 Corpus Christi Tex
W E Barnett Box 131 Brookhaven Miss
Barry Well Drlg Co West Star Rt Fallon Nev
Robert M Bass Drlg Contr Box 471 Kilgore Tex
Bateman & Whitsitt Inc Box 1956 Hobbs N M
Bayou Well Works Inc Box 78 New Iberia La
Beckman Inc Box 1524 Muskogee Okla
M E Billings Well Serv Inc 928 E 15th St Casper Wyo
J W (Johnny) Birdwell Well Serv Box 201 Kamay Tex
Bivin & Smoot Drlg Co Box 147 Overton Tex
Black Gold Well Serv Box 1427 OCS Lafayette La
Blackwell & Sunde Co 3135 Cherry Ave Long Beach 7 Calif
Bowie Well Serv Box 388 Bowie Tex

C

C & C Oil Field Serv Co Box 191 Oil City La
C B S Workover Co 1713 N Esperson Bldg Houston Tex
Cactus Well Serv Box 222 Snyder Tex
Camden Drlg Co Box 1418 Corpus Christi Tex
R L Carpenter Box 452 Sapulpa Okla
Carroll Drlg Co Inc Box 337 Farmington N Mex
Carter Well Serv Box 178 Pettus Tex
Chambless-Rosen Drlg Co Box 4294 Oklahoma City 9 Okla
Chandler Well Serv Co Box 231 El Reno Okla
Chase Well Serv Inc Box 126 Chase Kans
Clarke Oil Well Serv Co Box 2315 Hobbs N Mex
Clinch Drlg Co Box 27 Hazlehurst Miss
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Cook's Well Serv Inc 3118 S Third Abilene Tex
R A Cooper Drlg Co Inc 711 Hulman Bldg Evansville Ind
Copeland & Feller Well Serv Box 237 Kenedy Tex
Cramer Well Serv 503 N Creek Drumright Okla
Cron & Gracey Corp 1100 Houston Club Bldg Houston Tex

D

D & L Drlg Serv Box 121 Perryton Tex
Daniel & Langley Box 493 Smackover Ark

Dapsco Inc Box 918 Laurel Miss
Devonian Well Serv Box 2821 Odessa Tex
Douglas Drlg Co Box 748 Oildale Calif
Douglas V Downing Well Serv Box 206 Devine Tex
Drlg & Prod Co 2907 L St Bakersfield Calif
E B Duncan Drlg & Well Serv Co Inc Box 4096 Shreveport La

E

E & O Serv Co Inc Box 3066 Odessa Texas
King Edwards (Edwards Drlg Co) Box 1140 Graham Tex
Eichler Well Serv Box 515 Jacksboro Tex
Errol Elkins Drlg Co 460 Rio Grande St Eagle Pass Tex
Robert B Doe Oilfield Serv Rt 1 19030 James Rd Bakersfield Calif
Dood Emerson Well Serv & Gen Contrg 1328 S Broadway Sulphur Springs Tex

F

Forsan Well Serv Box A-584 Forsan Tex
Fruge Well Serv 1203 Center Vinton La

G

Tine Gaiser Drlg Co Box 1506 Bakersfield Calif
General Prod Serv Inc Box 442 Bakersfield Calif
General Well Drlg Inc Box 1315 Alice Tex
Gibson Drlg Co Box 1540 Kilgore Tex
Glenn Gillespie & Sons Box 907 Cushing Okla
C G Glasscock Drlg Co 1601 Wilson Tower Corpus Christi Tex
Glenn Drlg Co 38 Kennedy Bldg Tulsa Okla
Goldsmith Well Serv Inc Box 83 Goldsmith Tex
Leon Goswick & Co Box 107 Sweetwater Tex
Graham Bros Oil Well Serv Box 80 Brookhaven Miss
J P Graham Box 1307 Bay City Tex
E W Greer Box 191 Borger Tex
Gulf Tide Drlg Co Inc 450 Saratoga Bldg New Orleans La

H

H & W Well Serv Box 141 Perryton Tex
Hale-Cook Serv Co Inc Box 5064 Abilene Tex
Dick Hamm Drlg Co Box 575 Grandfalls Tex
Dave Harlin Drlg Co 107 Bramfield Bldg Snyder Tex
Harris Drlg Co Inc Box 868 Eunice La
Harrison Well Serv Box 21 Denver City Tex
Harvey Well Serv Inc Box 94 Harvey La
John Haseman Inc 419 Wilson Bldg Corpus Christi Tex
Win Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
Odell Herring Well Serv Box 401 Lindsay Okla
Hoffman Oil Well Serv Co Box 1167 Seminole Tex
Huval Well Serv 1601 Christine Pampa Tex

J

J-B Swabbing Co Inc Box 1166 Kilgore Tex
J & M Well Serv Box 445 Mission Tex
Neil Jackson & Sons Star Route East Artesia N Mex
Joe's Well Serv Box 612 Smackover Ark
Johnson Drlg & Serv Co Box 3 Magnolia Ark
F M Johnson Well Serv Box 613 Olney Tex
Lloyd Jones Drlg Co 700 Oil & Gas Bldg Wichita Falls Tex
Jones Well Serv Co 1201 McKinney Great Bend Kans

K

K B M Service Inc Box 1338 Williston N D
Kay Serv Co Box 123 Alvin Tex
Keeney Well Serv Co Box 44 Pleasanton Tex
Kern Drlg Co Inc Box 936 Magnolia Ark
Key & Martin Well Serv Box 624 Dewey Okla
C E Knight & Co Box 1688 Snyder Tex
Line Oil Well Serv Co Box 4447 Oklahoma City Okla

L

H J Lininger Box 37 Upper Sandusky Ohio
Locke Well Serv Box 312 Royalty Tex
Lodi Drlg & Serv Co Box 1669 Longview Tex

M

Mac Drlg Co Box 2972 Houston Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Maddox Prod Co 2909 Junipero Ave Long Beach 6 Calif
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
Curtis Martin Well Serv Box 447 Saint Jo Tex
Maxwell Well Serv Co Box 475 New London Tex

Mc

McAlister Well Serv Box 2214 Wichita Falls Tex
McCalman Drlg Co Inc Box 602 Homer La
McCasland Well Serv 109 N Avenue M Olney Tex
McDaniel Well Serv Box 456 Seminole Okla
McDonald Well Serv Box 2062 Abilene Tex
B M McGraw Drlg Contr 4412 N Western Oklahoma City Okla

M

Jack Mercer Well Serv Box 509 Nocona Tex
Box 7 Whitesboro Tex
Meyer's Well Serv Box 174 Pleasanton Tex
Miers Well Serv Inc Box 325 Sterling Colo
Mills Drlg Co Box 871 Seminole Okla
Mobile Well Serv Box 36 Cayuga Tex
Mohawk Oil Well Serv Box 1454 Alice Tex
Moore Prod Serv 1818 East "O" St Wilmington Calif

N

N & L Drlg Co Box 899 Ardmore Okla
Nichols & Freeman Well Serv Box 183 Grandfalls Tex

O

Oil Well Serv Co 2405 Orange Ave Long Beach 6 Calif
O'Loughlin Well Serv Co 1006 Locus St Perry Okla

P

Payne Bros Drlg Co Box 15 Lawrenceville Ill
Dean Penick Casing Pulling Box 5174 Midland Tex
L V Pennington Star Rt East Artesia N Mex
J E Perkins Inc Box 3143 Odessa Tex
Permian Well Serv Inc Box 37 Wink Tex
Pool Well Serv Co Box 1940 San Angelo Tex
Post & Brown Well Serv 208 S Main Stafford Kans
Potter Bros Box 1578 Kilgore Tex
W R (John) Potter Box 14 Kamay Tex
Price-Caudle Well Serv Inc Box 453 Seminole Okla
Price-Sitton Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
T M Pruett Drlg Contr Box 303 Centralia Ill

Q

Quad Drlg Co Box 974 Ardmore Okla

R

R & R Well Serv Co Box 637 Rangely Colo
R & R Well Serv Co Box 597 Nocona Tex
Ramey Well Serv 401-P Robertson Bldg Wichita Falls Tex
G H Ray Well Serv Co Box 68 Cement Okla
C M Roberson Drlg Co 418 Market Shreveport La
Rocket Well Serv 1706 Hill St Alvin Tex
Rocket Well Serv Inc Box 1107 Glendive Mont
Ross Const & Well Serv Box 278 Nocona Tex

S

San Juan Drlg Co Box 728 Farmington N Mex
Santa Fe Drlg Co Box 310 Whittier Calif
Savely Workover & Drlg Co Box 402 Rosenberg Tex
Scott's Well Serv Rural Rt 4 Hwy 9 E Seminole Okla
Shouse & Robinson Box 469 Okmulgee Okla
Signal Oilfield Serv Inc 415 Petroleum Club Bldg Denver Colo
Simmons Oilwell Serv 2432 Lemon Ave Signal Hill Calif
Smallwood & Son Drlg Co 3657 E Kiest Blvd Dallas Tex
Smith & Breyer 1521 Meadows Bldg Dallas Tex
K Smith Cable Tools 1801 Van Buren Great Bend Kans
Sooner Drlg Co 412 Federal Natl Bldg Shawnee Okla
Earl Sossamon Box 4146 Wichita Falls Tex
Spartan Well Serv 207 S & S Bldg Corpus Christi Tex
Spears Well Serv Co Box 3187 Victoria Tex
Spur Well Serv Co Box 1325 Houston Tex
Stafford Well Serv Box 208 Buffalo Wyo
Steitle Drlg Co 1312 Southwood Dr Alice Tex
Stewart's Casing Crew Box 14086 Houston Tex
Harold L Strader Drlg Co 3901 Mt Vernon Houston 6 Tex
Straube Drlg Co Box 730 Corsicana Tex
Sunnyland Contracting Co Inc Box 388 Rayne La
Sutton Producing Co Box 6446 San Antonio 9 Tex

T

T & H Well Serv Co Box 524 Eunice La
Dudley Elrod Taylor 118 Fifth Ave SE Cutbank Mont
Terminal Drlg & Prod Co 2975 Wilshire Blvd Suite 423 Los Angeles 5 Calif
Texas Drlg Co Box 183 Monahans Tex
Texas Workover & Oilwell Serv Co Box 32 Liberty Tex
Thornbrugh Well Serv Co Box 541 Natchez Miss
J R Todd Co Inc Box 168 Odessa Tex
Twinoak Drlg Co 210 S Morton Okmulgee Okla

U

Universal Oilwell Serv Inc Box 1092 Snyder Tex

V

Varner Oil Well Serv Box 253 Royalty Tex
Veeder Supply & Dev Co Box 201 Cherryvale Kans
Carl Vickers Well Serv 1716 Wilson Tower Corpus Christi Tex

W

W & C Well Serv 306 E Florida St Delhi La
W M & W Well Serv Co Box 931 Alice Tex
J H Wagner Drlg Co Box 751 El Dorado Kans
Weaver & Savage 1301 W Armory Blackwell Okla
Well Serv Inc 1901 E Virginia Ave Victoria Tex
Wells Drlg Co 5382 Cherry Ave Long Beach 5 Calif
Art West Drlg Co 205 O'Michael Bldg Odessa Tex
Chet Whaley Well Serv Co Inc 6006 Milart St Houston 21 Tex
Williams Well Serv Box 313 Stephens Ark
J C Williams Well Serv Co 603 S Arkansas Springhill La
Williamson Well Serv Inc Box 3828 Odessa Tex
Winnsboro Well Serv Box 102 Winnsboro Tex
G W Wittman 1303 N Alabama Okmulgee Okla
Sam E Wood Box 546 Alvin Tex
Wyoming Well Serv Inc Box 350 Cody Wyo

U. S. Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
ALABAMA							
Citronelle							
Dapsco Inc	5	Wisn Spr 38	Truck	1	12,500	12,000/2"	Yes
	14	Frnks 658 TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
Thornbrugh Well Serv Co	11	Wisn Spr	Truck	1	—	8,500/2" 7,500/2½"	—
	23	Ideco	Truck	1	12,500	—	—
ARKANSAS							
El Dorado							
Daniel & Langley	2	Wisn Sr	Truck	1	—	4,000/2" 3,500/2½"	
Smackover							
Daniel & Langley	1	Wisn Sr	Truck	1	—	4,000/2" 3,500/2½"	—
Joe's Well Serv	1	Crdwll H-1000	Truck	1	—	5,500/2" 5,000/2½"	No
	2	Frnks 5000	Truck	1	—	8,500/2" 8,000/2½"	No
	3	Cooper	Truck	1	8,500	—	No
Stephens							
Williams Well Serv	1	Wisn Spr	Truck	1	8,000	8,000/2" 6,000/2½" 5,000/3"	Yes
	2	Cooper	Truck	2	9,000	10,000/2" 8,000/2½" 6,500/3"	Yes
CALIFORNIA							
Bakersfield							
Adams Prod Serv	1	Wisn Spr Trcr	Trailer	2	10,000	11,500/2" 8,500/2½" 6,000/3"	Yes
Robt B Doe—Oilfield Serv	1	Crdwll H	Truck	1	4,500	5,000/2" 4,000/2½" 3,000/3	No
	2	Crdwll HL	Truck	2	5,500	6,000/2" 5,000/2½" 4,000/3"	No
	3	Hopper	Truck	1	3,000	3,000/2" 2,000/2½" 1,500/3"	No
	4	Hopper	Truck	1	4,000	4,500/2" 3,500/2½" 2,500/3"	No
	5	Hopper	Truck	1	2,500	2,500/2" 1,500/2½" 1,000/3"	No
	6	Hopper IGFA	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	No
	7	Hopper IGFA	Truck	2	9,000	7,000/2" 6,000/2½" 5,000/3"	No
Drlg & Prod Co	3	Ideco Rambler	Trailer	2	7,500	5,500/2" 5,000/2½" 4,50 /3"	No
General Prod Serv Inc	3	Hopper G	Truck	2	6,000	6,000/2" 4,000/2½" 3,000/3"	No
	7	Ideco 30	Trailer	2	10,000	10,000/2" 7,500/2½" 6,000/3"	No
	9	Hopper GTA	Truck	2	10,000	10,000/2" 7,500/2½" 6,000/3"	No
	11	Hopper GTA	Truck	2	13,000	15,000/2" 12,000/2½" 10,000/3"	No
Oil Well Serv Co	1	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	Yes
	1-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	2-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	4	Wisn Winch	Truck	2	4,000	4,000/2½" 3,500/3"	—
	11	Ideco 30	Trailer	2	10,000	10,000/2½" 8,000/3"	Yes
	12	Crdwll	Trailer	2	5,000	5,000/2½" 4,000/3"	—
	15	Ideco 30	Trailer	2	13,000	13,000/2½" 8,000/3"	Yes
Kernan							
Oil Well Serv Co	4-A	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	Yes
	41	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	—
	57	Ideco 30	Trailer	2	13,000	13,000/2½" 8,000/3"	Yes
Long Beach							
Blackwell & Sunde Co	1	Wgnr-Mrhse 1540	Trailer	2	12,200	14,000+/2" 12,500/2½" 9,500/3"	No
	2	Wgnr-Mrhse 1540	Trailer	2	12,200	14,000+/2" 12,500/2½" 9,500/3"	No
	3	Ideco H-30-AD	Trailer	2	12,200	14,000+/2" 12,500/2½" 9,500/3"	Yes
	4	Wisn CT 25SP	Trailer	2	12,200	14,000+/2" 12,500/2½" 9,500/3"	No
	5	Ideco TJ 440	Trailer	2	12,200	14,000+/2" 12,500/2½" 9,500/3"	Yes
	6	Crdwll RL-319	Truck	2	10,000	12,000+/2" 10,000/2½" 8,000/3"	No
	7	Crdwll RL-319	Truck	2	10,000	12,000+/2" 10,000/2½" 8,000/3"	No
	8	Crdwll KLGMD	Truck	2	8,000	8,000+/2" 5,000/2½" 4,000/3"	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity — Swabbing	Estimated Capacity — Pulling	Can Unit Also Drill?
Macrate Prod Co	1	Ideco H-30	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	Yes
	4	Wgnr-Mrhse 15-40	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	No
	6	Wgnr-Mrhse 15-40	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	No
	8	Wgnr-Mrhse 15-40	Trailer	2	12,000	14,000/2" 12,000/2½" 10,000/3"	Yes
Maddox Prod Co	1	Hopper	Truck	2	8,000	12,000/2" 9,000/2½" 7,000/3"	Yes
	2	Wlsn Spr	Trailer	2	10,000	17,000/2" 13,000/2½" 10,000/3"	Yes
	4	Wlsn Mogul	Trailer	2	13,000	17,000/2" 13,000/2½" 10,000/3"	Yes
Oil Well Serv Co	2	Wlsn Mogul	Truck	1	—	12,000/2½" 6,500/3"	Yes
	3	Ideco	Truck	2	13,000	13,000/2½" 7,000/3"	Yes
	5	Ideco	Trailer	2	5,000	5,000/2½" 4,000/3"	Yes
	6	Crdwll	Truck	2	10,000	7,000/2½" 6,500/3"	—
	7	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
	8	Wlsn	Truck	2	6,500	6,500/2½" 4,500/3"	—
	9	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
	14	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
Simmons Oilwell Serv	1	Ideco H-30AD	Truck	2	11,000	10,000/2½"	No
	2	Hopper IG-TA	Self-prop	2	10,000	8,000/2½"	No
Ventura							
Terminal Drlg & Prod Co	10	Ideco Rambler	Truck	2	13,000	11,500/2½"	Yes
Wilmington							
Moore Prod Serv	1	Crdwll	Trailer	2	6,000	8,000/2" 6,000/2½" 5,000/3"	Yes
	2	Hopper Hoist	Truck	2	10,000	10,000/2" 10,000/2½" 9,000/3"	Yes
Terminal Drlg & Prod Co	11	Frnks 65-44	Truck	2	12,000	10,745/2½"	No
	13	Ideco H-30	Truck	2	11,000	9,420/2½"	No
	15	Ideco	Truck	2	12,000	10,600/2½"	Yes
	16	Wlsn	Truck	2	15,000	15,000/2½"	No
	19	Ideco H-30	Truck	2	13,500	13,400/2½"	Yes
	22	Crdwll RL	Truck	2	10,000	10,000/2½"	Yes
	23	Crdwll HL	Truck	2	7,200	5,000/2½"	No
		COLORADO					
Ft Morgan							
Atlas Well Serv Inc	1	Frnks Rocket	Truck	2	8,000	8,500/2" 7,500/2½" 6,000/3"	Yes
Rangley							
R & R Well Serv Co	1	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	2	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	3	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	4	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	5	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	6	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	7	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	8	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	9	Frnks 658TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
Sterling							
Miers Well Serv Inc	1	Frnks Cruiser	Truck	2	10,000	12,000/2" 10,000/2½" 8,500/3"	Yes
	2	Frnks Cruiser	Truck	1	8,000	7,500/2" 6,000/2½" 5,000/3"	No
	3	Frnks Rocket	Truck	2	10,000	12,000/2" 10,000/2½" 8,500/3"	Yes
	4	Frnks Rocket	Truck	2	10,000	12,000/2" 10,000/2½" 8,500/3"	Yes
	5	Frnks Cruiser	Truck	2	10,000	12,000/2" 10,000/2½" 8,500/3"	Yes
Signal Oilfield Serv Inc	2	Frnks 658/44	Truck	2	10,000	—	Yes
		KANSAS					
Chase							
Chase Well Serv Inc	1	Frnks 4000TM	Truck	1	—	5,000/2" 4,500/2½" 3,600/3"	—
	2	Frnks 44TM	Truck	1	—	6,000/2" 5,500/2½" 4,500/3"	—
Larned							
Post & Brown Well Serv	7	Frnks	Truck	1	6,000	5,000/2½"	No
	15	Frnks	Truck	1	6,000	5,000/2½"	No
Plainville							
B K Well Serv	1	Frnks	Truck	2	7,000	7,000/2" 7,000/2½" 5,000/3"	No
	2	Frnks TM44	Truck	1	7,000	7,000/2" 7,000/2½" 5,000/3"	No
	3	Crdwll H	Truck	1	5,000	5,000/2" 5,000/2½" 4,000/3"	No
Chase Well Serv Inc	3	Frnks 65TM	Truck	1	—	8,000/2" 7,000/2½" 6,000/3"	—
	4	Frnks 44TM	Truck	1	—	6,000/2" 5,500/2½" 4,500/3"	—
Post & Brown Well Serv	9	Frnks 55	Truck	1	7,000	6,000/2½"	No
	12	Crdwll	Truck	1	6,000	5,000/2½"	No
	14	Frnks 55	Truck	1	7,000	6,000/2½"	No
	18	Frnks	Truck	1	8,000	7,000/2½"	No
	20	Frnks	Truck	1	8,000	7,000/2½"	No
	22	Cooper	Truck	2	6,000	5,000/2½"	Yes
Pratt							
Chase Well Serv Inc	6	Frnks DTM	Truck	2	—	6,000/2" 5,500/2½" 4,500/3"	No
Stafford							
Post & Brown Well Serv	6	Crdwll	Truck	1	6,000	5,000/2½"	No
	17	Frnks	Truck	1	6,000	5,000/2½"	No
	19	Frnks	Truck	1	6,000	5,000/2½"	No
Winfield							
B & G Well Serv	52	Crdwll AH	Truck	1	5,000	5,000/2½"	No
	83	Crdwll H	Truck	1	4,500	4,500/2½"	No
	94	Cooper	Truck	2	6,000	4,500/2½"	No
	107	Crdwll AH	Truck	2	6,500	4,500/2½"	No
		LOUISIANA					
Delhi							
W & C Well Serv	1	Wichtex C-60-HD	Truck	2	6,000	7,000/2" 5,000/2½"	Yes
	2	Wichtex C-60-HD	Truck	2	6,000	7,000/2" 5,000/2½"	Yes
	3	Wichtex C-60-HD	Truck	2	6,000	7,000/2" 5,000/2½"	Yes
Eunice							
T & H Well Serv Co	3	Wlsn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	5	Wlsn Spr	Truck	1	—	10,000/2" 8,000/2½"	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
	16	Wisn Spr	Truck	1	12,000	—	No
	18	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	20	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	25	Wisn Spr	Truck	1	12,000	—	No
	30	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	39	Wisn Spr	Truck	1	10,000	—	No
	40	Wisn Spr	Truck	1	12,300	—	No
	51	Wisn Spr 38	Truck	1	—	10,000/2½"	No
Harvey							
Bayou Well Works Inc	70	Brwstr	Truck	1	15,000	—	—
Lafayette							
Black Gold Well Serv	1	Crdwll H	Skid Mt'd	1	(Concentric Tubing)		No
	2	Wisn	Trailer	1	(Concentric Tubing)		No
	3	Cooper	Skit Mt'd	1	(Concentric Tubing)		No
New Iberia							
Bayou Well Works Inc	37	Cooper	Truck	1	12,500	—	—
	51	Wisn	Truck	1	12,500	—	—
	63	Wisn	Truck	1	12,500	—	—
Oil City							
B & B Oil Well Serv	1	—	Truck	2	2,500	2,750/2" 2,500/2½"	No
	2	—	Truck	1	2,500	2,000/2" 2,000/2½"	No
C & C Oil Field Serv Co	1	Wisn Sr	Truck	2	5,000	5,000/2" 3,500/2½" 2,500/3"	No
	2	Wisn Sr	Truck	2	5,000	5,000/2" 3,500/2½" 2,500/3"	No
	3	Wisn Sr	Truck	1	—	5,000/2" 3,500/2½" 2,500/3"	No
	4	Wisn Sr	Truck	1	—	5,000/2" 3,500/2½" 2,500/3"	No
	5	Wisn Sr	Truck	1	—	5,000/2" 3,500/2½" 2,500/3"	No
	6	Wisn Sr	Truck	1	—	5,000/2" 3,500/2½" 2,500/3"	No
Shreveport							
A A A Well Serv Co Inc	1	Cooper P-32	Truck	1	—	6,000/2" 4,500/2½"	No
	2	Cooper P-42	Truck	1	12,500	—	No
	3	Wisn Sr	Truck	2	5,000	5,000/2" 3,500/2½"	Yes
	4	Brwstr 70	Truck	1	11,000	—	No
E B Duncan Drlg & Well Serv Co Inc	1	Frnks 5000	Truck	1	—	6,500/2½"	Yes
Springhill							
J C Williams Well Serv Co	1	Wisn Sr	Truck	1	—	3,100/2½"	No
	2	Wisn Spr	Truck	1	6,000	—	No
	4	Wisn Spr	Truck	1	—	7,500/2½"	Yes
	5	Wisn Spr	Truck	2	10,000	7,500/2½"	Yes
	7	Wisn Spr	Truck	1	10,000	—	No
	8	Wisn Spr	Truck	1	—	8,500/2½"	No
Thibodaux							
Bayou Well Works Inc	58	Wisn	Truck	1	12,500	—	—
Venice							
Bayou Well Works Inc	Bge 1	Wisn	barge	1	12,500	—	—
MISSISSIPPI							
Baxterville							
Dapsco Inc	4	Wisn Spr	Truck	1	9,000	—	No
	5B	Wisn Spr	Truck	1	9,500	—	No
	6	Beth S-40	Truck	1	9,500	10,000/2" 10,000/2½"	No
	12	Frnks 658TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
	10	Frnks 658TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
Bolton							
Graham Bros Oil Well Serv	3	Wisn Spr	Truck	1	—	12,000/2" 10,000/2½" 8,000/3"	No
Brookhaven							
W E Barnett	1	Wisn Spr	Truck	1	7,000	11,000/2" 11,000/2½"	No
	2	Wisn Spr	Truck	1	—	11,000/2" 11,000/2½"	No
	3	Wisn Spr 38	Truck	1	—	11,000/2" 11,000/2½"	No
Graham Bros Oil Well Serv	1	Wisn Spr	Truck	—	13,000	—	—
Heidelberg							
Dapsco Inc	7	Frnks 658TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
Laurel							
Dapsco Inc	6B	Wisn Mogul	Truck	1	12,500	—	No
	7B	Wisn Spr	Truck	1	9,000	—	No
	8	Frnks 658TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
	9	Frnks 658TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
	9B	Wisn Spr	Truck	1	11,500	—	No
	11	Frnks 658TM	Truck	1	12,500	12,000/2" 12,000/2½"	Yes
Natchez							
Graham Bros Oil Well Serv	40	Crdwll K	Truck	1	—	15,000/2" 13,500/2½" 10,000/3"	No
Thornbrugh Well Serv Co	1	Wisn Spr	Truck	1	9,000	—	—
	14	Wisn Spr	Truck	1	10,000	—	—
	15	Wisn Spr	Truck	1	—	8,500/2" 7,500/2½"	—
	16	Wisn Spr	Truck	1	—	8,500/2" 7,500/2½"	—
	18	Cooper 38	Truck	1	10,000	10,000/2" 9,000/2½"	—
	20	Wisn Spr 38	Truck	1	—	12,000/2" 10,000/2½"	—
MONTANA							
Cut Bank							
Dudley Elrod Taylor	3	Crdwll AH	Truck	2	7,000	5,000/2½"	—
	4	Frnks 26	Truck	1	—	3,200/2½"	—
Glendive							
K B M Well Serv Inc	3	Crdwll H	Truck	1	7,500	6,500/2" 5,000/2½"	No
	5	Wisn Mogul 42	Truck	1	15,000	15,000/2" 12,000/2½"	No
	8	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
Rocket Well Serv	1	Frnks 658	Truck	2	10,500	12,000/2" 10,500/2½"	Yes
	2	Frnks 658	Truck	1	—	10,000/2" 9,000/2½"	Yes
Signal Oilfield Serv Inc	10	Frnks 658/65	Truck	2	12,000	—	Yes
	14	Frnks 658/65	Truck	2	10,000	—	No
NEW MEXICO							
Artesia							
Neil Jackson & Sons	1	Wisn	Truck	1	4,000	—	No
	2	Crdwll	Truck	2	3,500	3,500/2" 3,000/2½" 2,500/3"	No
	3	Wisn Spr	Truck	2	6,000	6,000/2" 5,000/2½" 4,000/3"	No
L V Pennington	1	Frnks Sr	Truck	2	5,000	5,000/2" 4,000/2½" 3,600/3"	
	1	Wisn S	Truck	2	5,000	5,000/2" 4,000/2½" 3,600/3"	—
Farmington							
Bivin & Smoot Drlg Co	3	Frnks Rocket	Truck	2	10,000	10,000/2" 10,000/2½" 7,500/3"	Yes
Signal Oilfield Serv Inc	6	Frnks 65/44	Truck	2	8,000	—	Yes
Hobbs							
Albright Well Serv Co	4	Frnks 65	Truck	1	11,000	10,000/2"	Yes
	5	Frnks 65	Truck	1	11,000	10,000/2"	Yes
	12	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½"	Yes
	17	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	23	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
	27	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	34	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
Bateman & Whitsitt Inc	1	Crdwll K	Truck	1	11,000	—	No
	10	Hopper GXFA	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	15	Frnks 658	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	20	Frnks 658	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	25	Frnks 7000	Truck	1	—	15,000/2" 12,500/2½" 9,000/3"	No
	30	Frnks 658	Truck	2	13,500	15,000/2" 12,500/2½" 9,000/3"	No
	35	Frnks 658	Truck	2	13,500	15,000/2" 12,500/2½" 9,000/3"	No
	40	Frnks 658	Truck	2	13,500	15,000/2" 12,500/2½" 9,000/3"	No
	45	Hopper GXFA	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	50	Hopper GXFA	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
Clarke Oil Well Serv Co	1	Frnks 658	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	2	Frnks 658	Truck	2	12,000	14,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	4	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	5	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	6	Frnks 658	Truck	2	12,000	14,000/2" 12,000/2½" 10,000/3"	No
	7	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	9	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	10	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
NORTH DAKOTA							
Keene							
K B M Well Serv Inc	4	Wisn Mogul 42	Truck	1	15,000	15,000/2" 12,000/2½"	No
	6	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
	7	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
	10	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
Tioga							
K B M Well Serv Inc	1	Frnks 658 DTM2	Truck	2	13,500	15,000/2" 12,000/2½"	No
	2	Frnks 658 DTM2	Truck	2	13,500	15,000/2" 12,000/2½"	No
	9	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
	11	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
OKLAHOMA							
Blackwell							
Weaver & Savage	R&T 1	Crdwll H	Truck	1	—	7,000/2" 5,000/2½" 4,500/3"	No
	DD 1	Frnks 44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	No
	DD 2	Frnks 65	Truck	2	12,000	12,000/2" 10,000/2½" 7,000/3"	No
	R&T 2	Crdwll H	Truck	1	—	7,000/2" 5,000/2½" 4,500/3"	No
Cement							
G H Ray Well Serv Co	1	Wisn Master	Truck	1	8,000	8,000/2½"	No
	5	Crdwll RL	Trailer	2	12,000	12,000/2½"	Yes
	6	Crdwll S-60	Truck	1	8,000	8,000/2½"	No
	7	Wisn Spr	Trailer	2	12,000	12,000/2½"	Yes
	8	Crdwll S-230	Truck	1	8,000	8,000/2½"	No
Weaver & Savage	DD 3	Frnks 44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	No
Chandler							
Chandler Well Serv Co	101	Frnks 44DTM	Truck	2	5,500	8,000/2" 6,500/2½"	No
	107	Frnks 44DTM	Truck	2	6,000	8,500/2" 6,500/2½"	Yes
	126	Frnks 44DTM	Truck	2	6,000	8,500/2" 6,500/2½"	Yes
Dewey							
Key & Martin Well Serv	1	Cooper W-S	Truck	1	2,000	3,000/2" 2,500/2½" 2,000/3"	No
	2	Cooper W-S	Truck	1	5,000	2,500/2" 2,000/2½" 1,500/3"	No
Drumright							
Cramer Well Serv	1	Frnks 65	Truck	2	6,000	7,500/2" 5,000/3"	No
	2	Frnks 5000	Truck	2	6,000	7,500/2" 5,000/3"	No
	3	Frnks 65	Truck	1	—	10,000/2"	No
	4	Frnks 65	Truck	1	—	7,500/2"	No
	5	Frnks 65	Truck	2	6,000	7,500/2" 5,000/3"	No
	6	Frnks 65	Truck	2	6,000	7,500/2" 5,000/3"	No
Hobart							
Earl Sossamon	1	Wlkr-Nr C-23	Trailer	2	5,000	4,000/2" 3,500/2½" 2,500/3"	Yes
Lindsay							
Odell Herring Well Serv Inc	2	Frnks 658	Truck	1	13,500	—	No
	3	Frnks 658	Truck	2	13,500	12,000/2" 12,000/2½"	No
	4	Frnks 658	Truck	2	13,500	12,000/2" 12,000/2½"	No
	5	Frnks 658	Truck	2	13,500	12,000/2" 12,000/2½"	No
	11	Frnks Rocket	Truck	2	13,500	16,000/2" 14,000/2½"	Yes
Okmulgee							
G W Wittman	3	Cooper W-226	Truck	2	3,650	4,000/2" 3,200/2½"	No
Perry							
O'Loughlin Well Serv Co	101	Frnks 65	Truck	2	7,000	7,000/2" 7,000/2½" 6,000/3"	No
	102	Frnks 65	Truck	1	7,000	7,000/2" 7,000/2½" 6,000/3"	No
Sapulpa							
R L Carpenter	1	Cooper W	Truck	1	3,000	3,000/2" 2,500/2½" 2,000/3"	No

When Knowhow is Needed ...

measure mud service by

MILWHITE

mud sales company

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
Seminole							
McDaniel Well Serv	1	Frnks 65-DTM	Truck	2	6,500	10,000/2" 6,500/2½"	No
	2	Frnks 65-DTM	Truck	2	6,500	10,000/2" 6,500/2½"	No
	3	Frnks 44-DTM	Truck	2	5,500	10,000/2" 6,500/2½"	No
Mills Drlg Co	U-1	Crdwll K-203	Truck	2	10,000	12,000/2" 12,000/2½"	—
	U-2	Crdwll K-203	Truck	2	10,000	12,000/2" 12,000/2½"	—
Price-Caudle Well Serv Inc	1	Frnks 65	Truck	1	—	10,000/2" 10,000/2½" 10,000/3"	No
	2	Frnks 44	Truck	1	8,000	10,000/2 10,000/2½" 10,000/3"	Yes
	3	Frnks 44	Truck	2	8,000	10,000/2" 10,000/2½" 10,000/3"	Yes
Scott's Well Serv	6	Frnks DTM-658	Truck	2	12,000	12,000/2½"	No
	7	Frnks TM-44	Truck	1	—	8,000/2½"	No
	8	Frnks TM-44	Truck	1	—	6,000/2½"	No
	9	Frnks DTM-44	Truck	2	8,000	6,000/2½"	No
	10	Frnks TM-44	Truck	1	—	6,000/2½"	No
TEXAS							
Abilene							
B-J Well Serv	1	Wlsn Spr	Truck	2	8,000	8,000/2" 6,000/2½" 5,000/3"	No
	2	Wichtex C-65	Truck	2	8,000	8,000/2" 6,000/2½" 5,000/3"	No
	3	Wichtex C-60	Truck	2	6,000	6,000/2" 4,500/2½" 3,800/3"	No
	4	Wichtex C-65	Truck	2	8,000	8,000/2" 6,000/2½" 5,000/3"	No
	5	Wichtex C-65	Truck	2	8,000	8,000/2" 6,000/2½" 5,000/3"	No
	6	Wichtex C-60	Truck	2	6,000	6,000/2" 4,500/2½" 3,800/3"	No
Cook's Well Serv Inc	—	Wichtex 57	Truck	2	7,500	7,500/2"	No
Hale-Cook Serv Co Inc	1	Wichtex	Truck	2	7,000	8,000/2½"	No
McDonald Well Serv	1	Frnks 44DTM	Truck	2	8,500	9,000/2" 6,000/2½"	Yes
	2	Frnks 44DTM	Truck	2	8,500	10,000/2" 7,000/2½"	Yes
	3	Wlsn Spr 38	Truck	2	8,500	10,000/2" 7,000/2½"	Yes
	4	Wichtex C-60	Truck	2	5,500	4,500/2" 3,000/2½"	No
Alice							
Mohawk Oil Well Serv	2	Wlsn Spr	Truck	2	10,000	9,000/2" 7,500/2½ 6,500/3"	Yes
	3	Wlsn Spr	Truck	2	10,000	9,000/2" 7,500/2½" 6,500/3"	Yes
	4	Wlsn Spr	Truck	2	10,000	9,000/2" 7,500/2½" 6,500/3"	Yes
	6	OCS	Truck	1	8,000	—	—
W M & W Well Serv Co	1	Wlsn Spr	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	Yes
	2	Allis Chmrs	Truck	2	8,000	10,000/2" 10,000/2½"	Yes
	3	Wlsn Spr	Truck	2	6,500	6,000/2" 5,000/2½"	Yes
	5	Wlsn Spr	Truck	2	7,500	6,500/2"	Yes
	7	Wlsn 38	Truck	2	8,500	8,800/2" 7,500/2½"	Yes
	9	Wlsn Spr	Truck	2	8,503	8,588/2" 7,000/2½"	Yes
Alvin							
Kay Serv Co	5	Wlsn Mogul	Truck	1	11,000	—	—
	6	Wlsn Sr	Truck	1	5,500	—	—
Rocket Well Serv	1	Frnks 65TM	Truck	1	—	9,500/2"	Yes
Sam E Wood	1	Ideco H-20	Truck	2	—	11,000/2" 9,000/2½"	Yes
	2	Wlsn Gnt	Trailer	1	—	14,000/2" 13,000/2½"	Yes
Andrews							
Pool Well Serv Co	7	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	12	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	19	Wlsn Spr	Truck	1	10,000	—	—
	27	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	Yes
	30	Wlsn Spr 38	Truck	2	12,000	14,000/2½"	No
Williamson Well Serv Inc	18	Frnks 658	Truck	2	13,500	13,500/2½"	No
	19	Frnks 658	Truck	2	13,500	13,500/2½"	No
	20	Frnks 658	Truck	2	13,500	13,500/2½"	No
	21	Frnks 658	Truck	2	13,500	13,500/2½"	No
	26	Frnks 658	Truck	2	13,500	13,500/2½"	No
	33	Frnks 658	Truck	2	13,500	13,500/2½"	No
	37	Frnks 658	Truck	2	13,500	13,500/2½"	No
Baytown							
Rocket Well Serv	11	Wlsn Spr	Truck	1	—	9,500/2"	Yes
Bay City							
J P Graham	12	Wlsn Spr	Truck	1	9,000	—	No
	18	Wlsn Spr	Truck	1	9,000	—	No
	26	Wlsn Spr	Truck	1	10,000	—	No
Big Lake							
Pool Well Serv Co	1	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	5	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	6	Wlsn Spr	Truck	1	10,000	—	No
	10	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	11	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	24	Wlsn Spr	Truck	1	10,000	—	No
	14	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	31	Frnks	Truck	2	12,000	14,000/2½"	No
Big Spring							
Forsan Oil Well Serv	183	Frnks 658DTM	Truck	2	12,000	13,000/2½"	Yes
Bowie							
Bowie Well Serv	2	Wichtex C-65	Truck	2	7,000	7,000/2½"	No
	3	Wichtex C-65	Truck	2	7,000	7,000/2½"	No
	4	Wichtex C-65	Truck	2	7,000	7,000/2½"	No
Bryson							
Eichler Well Serv	4	Wichtex C-60	Truck	2	5,000	5,000/2"	No
	5	Wichtex C-65	Truck	2	6,000	6,000/2"	No
Cayuga							
Mobile Well Serv	1	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
	5	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
	8	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
	9	Wlsn Spr	Truck	1	9,000	—	No
Charlotte							
Meyer's Well Serv	3	Wlsn Spr	Truck	2	7,500	7,500/2" 6,000/2½"	—
Colorado City							
W & C Well Serv	4	Wlsn Spr 38S	Truck	2	10,000	10,000/2" 8,000/2½"	Yes
	5	Wlsn Spr 38S	Truck	2	10,000	10,000/2" 8,000/2½"	Yes
	6	Wlsn Spr 38S	Truck	2	10,000	10,000/2" 8,000/2½"	Yes
Conroe							
Spur Well Serv Co	2	Frnks 65-TD	Truck	1	—	8,000/2½"	Yes
Corpus Christi							
Spartan Well Serv	1	Crdwll KL	Truck	1	—	10,000/2" 8,000/2½" 650/3"	—
	2	Crdwll K	—	1	6,000	—	—
Crane							
J R Todd Co Inc	4	Crdwll AL	Truck	2	9,000	8,000/2" 6,000/2½" 4,500/3"	No
	6	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	7	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	8	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
	9	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
Williamson Well Serv Inc	15	Frnks 658	Truck	2	13,500	13,500/2½"	No
	16	Frnks 658	Truck	2	13,500	13,500/2½"	No
	35	Frnks 658	Truck	2	13,500	13,500/2½"	No
Denver City							
B H B Superior Well Serv Inc	2	Cooper A142-42	Truck	2	13,000	14,000/2" 12,500/2½" 11,000/3"	Yes
	3	Cooper A142-42	Truck	2	13,000	14,000/2" 12,500/2½" 11,000/3"	Yes
	5	Cooper T420-48	Truck	2	14,000	16,000/2" 13,500/2½" 12,000/3"	Yes
Harrison Well Serv	1	Wisn Mogul	Truck	2	14,000	12,000/2½"	—
	2	Wisn Mogul	Truck	2	14,000	12,000/2½"	—
Devine							
Douglas V Downing Well Serv	1	Border Foundry	Truck	2	4,500	4,000/2" 3,500/2½" 2,500/3"	No
	2	Wisn Spr	Truck	2	7,000	7,000/2" 6,500/2½" 5,500/3"	Yes
	3	Wisn Spr	Truck	2	7,000	7,000/2" 6,500/2½" 5,500/3"	Yes
	4	Wisn Spr	Truck	2	7,000	7,000/2" 6,500/2½" 5,500/3"	Yes
	6	Wisn Sr	Truck	2	6,000	5,000/2" 4,500/2½" 3,500/3"	Yes
Meyer's Well Serv	1	Wisn Jr	Truck	2	4,500	4,500/2" 4,000/2½"	—
El Campo							
Kay Serv Co	4	Frnks	Truck	1	7,500	—	—
Forsan							
Forsan Oil Well Serv	11	Frnks 33	Truck	1	—	3,500/2½"	Yes
	33	Crdwll 856	Truck	1	—	3,500/2½"	Yes
	44	Frnks 44TM	Truck	1	—	6,500/2½"	Yes
	658	Frnks 658	Trailer-Truck	1	—	13,000/2½"	Yes
	856	Wisn Spr	Truck	2	11,000	10,000/2½"	Yes
Freer							
Douglas V Downing Well Serv	5	Frnks	Truck	2	4,500	4,000/2" 3,500/2½" 2,500/3"	No
Steitle Drlg Co	1	Wisn Mogul	Trailer	2	12,000	16,000/2½"	Yes
Goldsmith							
Goldsmith Well Serv Inc	1	Wisn Mogul	Truck	2	15,000	10,000/2½"	No
	2	Wisn 38	Truck	2	11,600	8,000/2½"	No
Grandfalls							
Nichols & Freeman Well Serv	4	Wisn Sr	Truck	2	4,500	5,000/2" 4,000/2½" 2,500/3"	No
	6	Wisn Sr	Truck	2	4,500	4,000/2" 3,500/2½" 2,500/3"	No
	14	Wisn Sr	Truck	2	5,000	5,000/2" 4,000/2½" 3,300/3"	No
	15	Wisn Spr	Truck	1	—	8,000/2" 5,000/2½" 4,000/3"	No
	22	Wisn Spr 38	Truck	2	11,000	10,000/2" 10,000/2½" 7,000/3"	No
High Island							
Kay Serv Co	1	Wisn Mogul	Truck	1	11,000	—	—
Houston							
Spur Well Serv Co	1	Frnks 65-TD	Truck	1	—	8,000/2½"	Yes
Stewart's Casing Crew	1	Cooper E	Truck	1	—	8,000/2" 6,500/2½"	Yes
	3	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	5	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	6	Cooper 420	Truck	1	—	11,000/2" 9,000/2½	Yes
	7	Cooper TR-42	Truck	1	—	10,000/2" 8,000/2½"	No
	8	Cooper AP-138	Truck	1	—	10,000/2" 8,000/2½"	No
	9	Frnks	Skid Mt'd	1	—	10,000/2" 8,000/2½"	Yes
Kamay							
W R (John) Potter	1	Wisn Spr	Truck	1	—	6,000/2" 5,500/2½"	No
	3	Wisn Master	Truck	2	5,500	6,700/2" 6,000/2½"	Yes
J W (Johnny) Birdwell Well Serv	2	Wisn Master	Truck	2	5,500	5,500/2"	Yes
	3	Wichtex C-65	Truck	2	6,500	6,500/2"	Yes
	4	Wikr-Nr	Truck	1	4,500	4,500/2"	No
	5	Wichtex C-65	Truck	2	6,500	6,500/2"	Yes
Kenedy							
Copeland & Fuller Well Serv	1	Wisn Spr 38	Truck	2	8,000	8,500/2" 7,500/2½"	Yes
	2	Cooper A-38	Truck	2	8,000	10,000/2" 8,500/2½"	Yes
Kilgore							
Bivin & Smoot Drlg Co	2	Wisn Mogul	—	2	11,500	10,000/2" 10,000/2½" 7,500/3"	Yes
Potter Bros	1	Wisn Spr	Truck	1	—	7,500/2" 6,500/2½" 5,500/3"	Yes
	2	Crdwll	Truck	1	4,000	7,500/2" 6,500/2½" 5,500/3"	Yes
	4	Wisn Spr	Truck	1	—	5,000/2" 4,500/2½" 4,000/3"	No
J-B Swabbing Co Inc	2	Wisn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
	3	Cooper E	Tractor	1	5,000	6,000/2" 5,000/2½"	Yes
	5	Wisn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
	6	Wisn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
	7	Wisn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	No
	9	Wisn Mogul	—	1	12,000	10,000/2" 9,000/2½"	Yes
	10	Wisn Spr Mogul	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
	19	Wisn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
Liberty							
Texas Workover & Oilwell Serv Co	3	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	4	Wisn Spr	Truck	1	10,000	—	No
	5	Wisn Spr	Truck	1	10,000	—	No
Lodi							
Lodi Drlg & Serv Co	1	Wisn Spr	Truck	1	7,500	—	No
	2	Wisn Spr	Truck	1	—	7,000/2½"	Yes
	4	Wisn Spr	Truck	1	9,000	—	No
	5	Wisn Spr 38	Truck	1	—	9,000/2½"	Yes
	7	Wisn Spr 38	Truck	1	—	9,000/2½"	Yes
Midland							
Dean Penick Casing Pulling	1	Wisn Spr	Truck	1	—	10,000/2" 10,000/2½" 10,000/3"	No
Pool Well Serv Co	15	Wisn Spr 38	Trailer	2	12,000	14,000/2½"	No
	17	Wisn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	22	Wisn Mogul 42	Trailer	2	14,000	14,000/2½"	No
Williamson Well Serv Inc	27	Frnks 658	Truck	2	13,500	13,500/2½"	No
	28	Frnks 658	Truck	2	13,500	13,500/2½"	No
	30	Frnks 658	Truck	2	13,500	13,500/2½"	No
	31	Frnks 658	Truck	2	13,500	13,500/2½"	No
Mabank							
Mobile Well Serv	6	Wisn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
Mission							
J & M Well Serv	6	Cooper L-145	Trailer	2	8,500	12,000/2" 10,000/2½"	Yes
	9	Cooper T-36	Truck	1	10,000	—	No
New London							
Maxwell Well Serv Co	1	Wisn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	No

NEW NEW NEW

The FRANKS SPECIAL YOU'VE BEEN WATCHING FOR

FRANKS EXPLORER

THE EXPLORER IS DESIGNED FOR TODAYS SERVICING AND WORKOVER

AND IS NOT A TEN YEAR OLD MODEL WITH A SOUPED-UP RATING

STAR FEATURES

- INDUSTRIAL ENGINE — Waukesha, Cummins, G.M. or equivalent up to 400 H.P.
- NEW MAIN DRUM DESIGN for fastest, safest pulling.
- NEW WATER AND AIR COOLING BRAKE SYSTEM. (Pat. applied for.)
- NEW HARDENED, REMOVABLE FLOATING BRAKE RIMS.
- NEW CONTROLS for easier, faster, safer handling.
- ALL MODELS AVAILABLE WITH TORQUE CONVERTERS.

Power with a punch to 400 horses, smoothness with converter and torqmatic drive optional. All driving through Franks PTO with oil bath drive. The most powerful self-propelled servicing and workover rig offered.

Powerful with all new special frame, more capacity rear bogies, new removable sandreel, new guards with new look, engine and power train components easily accessible for maintenance, new fabricating method for strength with more power-to-weight ratio, improved air controls, new axle application and special spring and rocker beam suspension, Franks improved power steering.

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There are four Explorer models, all new, with industrial power, warranted all new Man-Ten steel frame (no more broken backs), lower center of gravity load, heavier drive lines and power trains.

You'll need more information to fully understand all the Explorer has to offer you. Call a Franks representative for further details.

A GOOD CREW NATURALLY DOES FASTER, SAFER JOBS WITH **Good equipment**

WELL SERVICING AND DRILLING UNITS
FRANKS
DIVISION OF CABOT
PAMPA, TEXAS

Write or call collect
for full information

FRANKS DIVISION
Cabot Shops, Inc.
Pampa, Texas

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
	2	Wisn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	Yes
	3	Wisn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	No
	4	Wisn Spr	Skid	1	4,500	—	—
	5	Wisn Spr	Skid	1	9,500	—	—
Nocona							
Jack Mercer Well Serv	2	Wisn Sr	Truck	1	—	3,000/2" 2,500/2½" 2,500/3"	No
	6	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	7	Wichtex C-65	Truck	2	7,500	7,500/2" 7,500/2½" 6,500/3"	Yes
	8	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	15	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	18	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	20	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	33	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
R & R Well Serv Co	2	Wichtex	Truck	2	3,000	—	No
	4	Wichtex	Truck	2	3,000	—	No
Ross Constr & Well Serv	2	Wichtex	Truck	2	8,000	7,000/2" 5,400/2½"	No
	5	Wichtex	Truck	2	8,000	—	No
	8	Crdwll	Truck	2	12,000	8,000/2" 7,000/2½"	Yes
Novice							
Pool Well Serv Co	9	Wisn Sr	Truck	2	6,500	5,000/2½"	No
Odessa							
Devonian Well Serv	6	Frnks 658	Truck	6	14,000	15,000/2" 14,000/2½" 11,000/3"	Yes
E & O Well Serv Co Inc	1	Crdwll S	Truck	1	13,500	—	No
J R Todd Co Inc	1	Frnks 658DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	2	Frnks 658DTM	Truck	1	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658 DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
Williamson Well Serv Inc	3	Frnks 658	Truck	2	13,500	13,500/2½"	No
	7	Frnks 658	Truck	2	13,500	13,500/2½"	No
	11	Frnks 658	Truck	2	13,500	13,500/2½"	No
	13	Frnks 658	Truck	2	13,500	13,500/2½"	No
	17	Frnks 658	Truck	2	13,500	13,500/2½"	No
	23	Frnks 658	Truck	2	13,500	13,500/2½"	No
	24	Frnks 658	Truck	2	13,500	13,500/2½"	No
	32	Frnks 658	Truck	2	13,500	13,500/2½"	No
	34	Frnks 658	Truck	2	13,500	13,500/2½"	No
	36	Frnks 658	Truck	2	13,500	13,500/2½"	No
Olney							
McCasland Well Serv	1	Wichtex 2TD	Truck	2	3,500	3,500/2" 2,500/2½" 1,500/3"	No
	1	Wichita Jr	Truck	2	3,500	3,500/2" 2,500/2½" 1,500/3"	No
Perryton							
D & L Drlg & Serv	1	Crdwll K-200	Truck	2	13,000	10,000/2½"	No
	3	Frnks 44	Truck	1	10,000	8,000/2½"	No
	4	Crdwll AH	Truck	2	11,000	10,000/2½"	No
H & W Well Serv	1	Wisn Spr	Truck	1	8,500	—	No
	3	Wisn Spr 38	Truck	2	11,500	10,000/2" 10,000/2½"	Yes
	5	Wisn Spr 38	Truck	2	11,500	10,000/2" 10,000/2½"	Yes
	7	Wisn Spr 38	Truck	2	13,500	12,000/2" 12,000/2½"	Yes
Pool Well Serv Co	18	Wisn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	20	Wisn Spr	Truck	2	10,000	8,000/2½"	No
	25	Wisn Spr 38	Trailer	2	14,000	12,000/2½"	No
Pettus							
Carter Well Serv	1	Wisn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
	2	Wisn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
	3	Wisn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
Plains							
B H B Superior Well Serv Inc	1	Cooper A142-42	Truck	2	13,000	14,000/2" 12,500/2½" 11,000/3"	Yes
	4	Cooper TR38-38	Truck	2	9,000	8,000/2" 7,000/2½" 6,000/3"	Yes
Pleasanton							
Keeney Well Serv Co	1	Crdwll	Truck	1	7,500	7,500/2"	Yes
	2	Wisn Sr	Truck	2	6,000	6,000/2"	Yes
	3	Wisn Spr	Truck	1	8,000	8,000/2"	Yes
Meyer's Well Serv	2	Wisn Spr	Truck	2	7,500	7,500/2" 6,000/2½"	—
Quitman							
J-B Swabbing Co Inc	8	Wisn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
Rio Grande City							
J & M Well Serv	2	Cooper E-563	Truck	2	5,500	6,500/2" 5,500/2½"	Yes
	3	Cooper E-563	Truck	2	5,500	6,500/2" 5,500/2½"	Yes
	4	Wisn Spr	Truck	2	6,000	7,500/2" 6,500/2½"	Yes
	5	Wisn Spr	Truck	2	6,000	7,500/2" 6,500/2½"	Yes
	7	Wisn Spr	Truck	2	6,000	8,500/2" 7,500/2½"	Yes
	8	Wisn Sr	Truck	2	5,000	4,500/2" 3,500/2½"	Yes
Rosenberg							
Savely Workover & Drlg Co	4	Frnks 658	Self-prop	1	—	13,500/2" 12,000/2½" 7,500/3"	No
Royalty							
Locke Well Serv	1	Wisn Spr	Truck	2	8,000	8,000/2" 8,000/2½" 8,000/3"	Yes
	2	Crdwll K	Truck	1	—	10,000/2" 7,000/2½" 5,000/3"	No
	3	Wisn Spr	Truck	2	10,000	10,000/2" 7,000/2½" 5,000/3"	Yes
Varner Oil Well Serv	1	Wikr-Nr P-25	Truck	2	6,000	6,000/2" 5,000/2½" 3,000/3"	No
	2	Wisn	Truck	2	—	3,000/2" 2,500/2½"	No
	3	Wisn	Truck	2	4,000	5,000/2" 4,000/2½" 3,000/3"	No
San Angelo							
Pool Well Serv Co	4	Wisn Spr	Truck	1	10,000	—	No
	16	Wisn Spr 38	Truck	2	12,000	10,000/2½"	No
	21	Wisn Spr	Truck	2	10,000	8,000/2½"	No
	26	Wisn Spr	Truck	2	6,500	5,000/2½"	No
Saint Jo							
Curtis Martin Well Serv	1	Wichtex C-60	Truck	2	6,000	6,000/2½"	No
	2	Cooper A-132	Truck	2	4,500	4,500/2½"	No
	3	Wisn Jr	Truck	2	3,000	3,000/2½"	No
Seminole							
Hoffman Oil Well Serv Co	1	Wisn Spr 38	Truck	2	—	8,000/2½"	Yes
	2	Wisn Mogul	Truck	2	—	10,000/2½"	Yes
	3	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
	4	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
	5	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity: Swabbing	Estimated Capacity: Pulling	Can Unit Also Drill?
	6	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
Seymour							
Bill Atchley	1	Wlsn Jr	Truck	2	7,000	6,000/2" 4,000/2½" 3,000/3"	No
	2	Wlsn Jr	Truck	2	7,000	6,000/2" 4,000/2½" 3,000/3"	No
Snyder							
Cactus Well Serv Co	1	Wlsn Spr	Truck	1	10,000	—	No
	3	Wlsn Spr 38	Truck	2	10,000	12,000/2" 10,000/2½" 8,000/3"	Yes
	7	Frnks 658 DTM	Truck	2	12,500	14,000/2" 12,000/2½" 10,000/3"	Yes
Leon Goswick & Co	6	Wlsn Spr	Truck	2	9,000	9,500/2" 8,000/2½"	No
	7	Wlsn Spr	Truck	2	9,000	9,500/2" 8,000/2½"	No
Universal Oilwell Serv Inc	136	Frnks 65 DTM2	Truck	2	11,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	146	Frnks 658	Truck	2	12,500	15,000/2" 12,000/2½" 10,000/3"	Yes
	182	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	204	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	218	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
Sulphur Bluff							
Dood Emerson Well Serv & Gen Contg	1	Cooper E-60	Truck	1	5,000	10,000/2" 7,500/2½"	Yes
Sulphur Springs							
Dood Emerson Well Serv & Gen Contg	2	Wlsn Spr	Truck	1	5,000	10,000/2" 7,500/2½"	Yes
Sweetwater							
Leon Goswick & Co	4	Crdwll HL 230	Truck	2	8,000	8,200/2" 6,500/2½"	No
	5	Wlsn Spr	Truck	2	9,000	9,500/2" 8,000/2½"	No
Pool Well Serv Co	3	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
Tucker							
Mobile Well Serv	4	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
Victoria							
Spears Well Serv Inc	1	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	2	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	3	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	4	Wlsn Spr	Truck	1	8,000	—	—
	5	Skytop Wltrwt	Truck	2	8,000	10,000/2" 8,000/2½"	Yes
	6	Skytop Wltrwt	Truck	2	8,000	10,000/2" 8,000/2½"	Yes
Well Serv Inc	1	Frnks TM65	Truck	1	—	8,500/2" 6,500/2½"	Yes
	2	Frnks TM65	Truck	1	—	8,500/2" 6,500/2½"	Yes
	3	Frnks TM 65	Truck	1	—	8,500/2" 6,500/2½"	Yes
Wichita Falls							
McAlister Well Serv	7	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	10	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	20	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	42	Wichtex	Truck	2	5,000	5,000/2" 3,600/2½"	No
	45	Wichtex	Truck	1	—	5,000/2" 3,600/2½"	No
Ramey Well Serv	1	Wichtex E-75	Truck	2	8,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	2	Wichtex E-75	Truck	2	8,000	14,000/2" 12,000/2½" 10,000/3"	Yes
Winnsboro							
Winnsboro Well Serv Co	F-1	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	F-2	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	W-4	Wlsn Spr	Truck	1	8,500	—	—
	F-5	Frnks Spr	Truck	1	—	8,500/2" 7,200/2½"	Yes
	F-6	Frnks 44	Truck	1	—	6,000/2" 5,000/2½"	Yes
Wink							
Permian Well Serv Inc	2	Wlsn Gnt	Truck	1	—	12,000/2" 10,000/2½" 8,000/3"	No
	3	Wlsn Spr	Truck	2	10,000	10,000/2" 8,500/2½" 6,500/3"	No
	6	Wlsn Spr	Truck	2	10,000	10,000/2 8,500/2½" 6,500/3"	No
Winters							
Pool Well Serv Co	2	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	8	Wlsn Sr	Truck	2	6,500	5,000/2½"	No
	23	Wlsn Spr	Truck	1	10,000	—	No
	28	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
WYOMING							
Casper							
M E Billings Well Serv Inc	1	Wlsn Mogul	Truck	1	11,000	—	—
Cody							
Wyoming Well Serv Inc	24	Frnks 65/44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	30	Crdwll KS	Truck	1	8,000	9,000/2" 7,500/2½" 5,000/3"	Yes
Grass Creek							
Wyoming Well Serv Inc	25	Crdwll	Truck	1	8,000	3,500/2" 3,000/2½" 2,500/3"	Yes
	23	Ideco 50-60	Truck	1	8,000	7,000/2" 6,000/2½" 4,000/3"	Yes
	28	Crdwll HS	Truck	1	8,000	5,000/2" 4,000/2½" 3,000/3"	Yes
Linch							
Stafford Well Serv	5	Frnks 65-44	Truck	2	9,000	9,000/2½"	Yes
	10	Frnks 65-44	Truck	2	9,000	9,000/2½"	Yes
	40	Frnks 65	Truck	1	—	10,000/2½"	Yes
	44	Frnks 658	Truck	2	14,500	14,500/2½"	Yes
Wyoming Well Serv Inc	22	Crdwll KS	Truck	1	9,000	8,000/2" 7,000/2½" 6,000/3"	Yes
	29	White L W	Truck	1	10,000	—	No
Riverton							
Stafford Well Serv	14	Frnks 65-44	Truck	2	9,000	9,000/2½"	Yes
Worland							
Stafford Well Serv	17	Frnks 65-44	Truck	2	9,000	9,000/2½"	Yes
	45	Frnks 658	Truck	2	12,000	12,000/2½"	Yes

U. S. Cable Tool Servicing Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	No. of Drums	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
COLORADO							
Sterling							
Signal Oilfield Serv Inc	4	dsl	125	2	—	7500	Crdwll RL
	5	dsl	125	2	—	7500	Crdwll RL
	11	gas	125	2	—	7500	Crdwll RL

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	No. of Drums	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ILLINOIS							
Lawrenceville							
Payne Bros Drlg Co	1	dsl	150	3	3000	4000	B Erie 36-L
	2	dsl	150	3	3000	4000	B Erie 36-L
	3	dsl	150	3	3000	4000	B Erie 36-L
KANSAS							
Butler County							
J H Wagner Drlg Co	2	gas-LPG	145	—	3500	4500	B Erie 36-L
Cowley County							
J H Wagner Drlg Co	3	gas-LPG	145	—	3500	4500	B Erie 36-L
Ellis County							
K Smith Cable Tools	1	gas-prop	145	3	3000	5000	Wlkr-Nr
Great Bend County							
Signal Oilfield Serv Inc	1	dsl	125	2	—	7500	Crdwll RL
	7	gas	125	3	—	5000	Wlkr-Nr
	9	dsl	125	2	—	7500	Crdwll RL
Elk County							
Veeder Supply & Dev Co BE	2	dsl	120	3	3500	4500	B Erie
MONTANA							
Cut Bank County							
Dudley Elrod Taylor	1	gaso	140	2	—	4000	Wisn Gnt
NEW MEXICO							
Farmington County							
Signal Oilfield Serv Inc	12	gas	125	2	—	7500	Crdwll RL
	13	gas	125	2	—	7500	Crdwll RL
Jal							
Art West Drlg Co	3	LPG	145	2	—	5500	Crdwll RL
	7	LPG	145	2	—	8000	Crdwll RL
OKLAHOMA							
Blackwell County							
Weaver & Savage	S-1	gas	145	2	—	7500	Crdwll RL
	S-3	gas	145	2	—	5000	Wisn Mogul
	S-4	gas	145	3	—	5000	Wlkr-Nr 43
	S-5	gas	145	3	—	5000	Wlkr-Nr 43
Creek							
M L (Mike) Marrs Drlg Co	1	LPG	145	—	3500	4500	B Erie 36-L
	2	LPG	145	—	3500	5000	B Erie 36-L
	4	LPG	145	—	3500	5000	B Erie 36-L
Fairfax							
Signal Oilfield Serv Inc	3	gas	125	2	—	7500	Crdwll RL
	8	gas	125	3	—	5000	Wlkr-Nr
Grant County							
Sooner Drlg Co	4	LPG	140	3	—	7000	Wlkr-Nr C-34
Hobart							
Earl Sossamon	2	gas	80	3	1500	2500	Wlkr-Nr S-32
Medford							
Sooner Drlg Co	2	LPG	140	3	—	7000	Wlkr-Nr C-34
Okmulgee County							
Shouse & Robinson	1	LPG	—	—	3500	4500	B Erie 28-L
	2	LPG	—	—	3500	4500	B Erie 36-L
Smallwood & Son Drlg Co	2	btne	—	3	3500	5600	B Erie 36-L
Pawnee County							
M L (Mike) Marrs Drlg Co	3	LPG	145	—	3500	5000	B Erie 36-L
Pike City							
Line Oil Well Serv Co	1	gas-gaso-LPG	245	2	7500	10,000	Crdwll RL
	5	gas-gaso-LPG	245	3	7500	10,000	Crdwll RL
	6	gas-gaso-LPG	140	2	4500	5000	Crdwll K
Seminole							
Mills Drlg Co	6	gas-LPG	145	2	—	7500	Crdwll RL
	7	gas-LPG	145	3	—	7500	Crdwll RL
	8	gas-LPG	145	3	—	4500	Wlkr-Nr S-43
OHIO							
Hocking							
R A Cooper Drlg Co	1	gas	—	—	4000	4000	Natl 12
Wood							
H J Lininger	2	dsl	175	—	3500	—	L C Moore
Wyandot							
H J Lininger	1	gas-gaso	78	—	2500	—	Beth Cyclone
	3	gas-gaso	65	—	1800	—	Beth Cyclone
TEXAS							
Abilene							
Cook's Well Serv Inc	—	btne	145	3	5000	7000	Wlkr-Nr
	—	btne	70	3	3000	3500	B Erie 28
Eagle Pass							
Errol Elkins Drlg Co	2	LPG	150	—	5000	6500	B Erie 36
	2	LPG	150	—	5000	6500	B Erie 36-L
Electra							
Lloyd Jones Drlg Co	1	gas-gaso-LPG	130	3	2000	4000	Wlkr-Nr C-32
Grand Falls							
Dick Hamm Drlg Co	1	btne	145	3	4500	7000	Wlkr-Nr S-33
	2	btne	140	3	—	3500	Wlkr-Nr C-33
McCamey							
C N Adkinsson Jr	1	LPG	100	3	2500	3000	B Erie 28-L
Odessa							
Art West Drlg Co	5	LPG	185	3	—	8500	Crdwll RL
	9	LPG	185	2	—	9000	Wisn Gnt
	10	dsl	125	2	—	8000	Crdwll RL
Olney County							
F M Johnson Well Serv	1	LPG	135	3	—	2000	Johnson Sp 30
	2	LPG	135	3	—	3500	Clark 30
	3	LPG	135	3	—	3500	Clark 30
	4	LPG	145	3	—	4500	Clark 30 Sp
	5	LPG	145	3	—	4500	Clark 30 Sp
Pampa							
Huval Well Serv	2	gas-gaso-btne	145	2	4400	4200	Wisn Mogul
Stinnett							
E W Greer	2	btne	145	2	5000	5000	B Erie 36-L
	3	btne	145	2	5000	5000	B Erie 36-L
	4	btne	140	2	5000	5000	Wichtex
Wichita County							
King Edwards Edwards Drlg Co	11	btne	150	3	5000	5000	Wlkr-Nr Spddr
Wichita Falls							
McAlister Well Serv	32	LPG	185	3	—	7000	Wlkr-Nr C-34
Wickett							
Art West Drlg Co	6	gas	145	2	—	8000	Crdwll RL
	8	gas	145	2	—	8000	Crdwll RL

U. S. Rotary Workover Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
ALABAMA						
Citronelle						
Thornbrugh Well Serv Co	22	dsl	225	Wisn Mogul 42	200	12,000
ARKANSAS						
Columbia County						
Kern Drlg Co Inc	3	dsl	260	Emsco GB-250	260	8,000
Lewisville						
Johnson Drlg & Serv Co	1	dsl	200	Beth Breeze	200	10,000
Miller County						
Kern Drlg Co Inc	1	dsl	260	Emsco GA-250	260	7,000
CALIFORNIA						
Bakersfield						
Drlg & Prod Co	1	dsl	325	Crdwll Trlrig	420	12,500
General Prod Serv Inc	10	dsl	300	Hopper GTA	300	7,500/2⅛"
	12	dsl	300	Hopper M	380	12,000/2⅛"
Oil Well Serv Co	1	dsl	300	Ideco 30	300	8,000
	1-A	dsl	500	Ideco 40	300	13,000
	2-A	dsl	400	Ideco 40	300	13,000
	11	LPG	400	Ideco 30	280	8,000
	15	LPG	400	Ideco 30	300	10,000
Kern County						
Douglas Drlg Co	1	btne	125	Emsco	125	2,500
Tine Gaiser Drlg Co	A	dsl	600	Natl 50	350	8,000
	B	dsl	800	Emsco GB-500	700	12,000
	C	btne	300	—	225	5,000
Kernan						
Oil Well Serv Co	4-A	dsl	300	Ideco 30	300	8,000
	57	dsl	300	Ideco 35 Drive In	300	12,000
Long Beach						
Blackwell & Sunde Co	3	btne	350	Ideco H-30-AD	250	6,000
	5	btne	350	Ideco TJ-440	250	6,000
	6	btne	350	Crdwll RL-319	152	4,500
Macrate Prod Co	2	dsl	190	Ideco H-30AD	190	6,000
	7	gas-LPG	300	Wgnr-Mrhse 15-40	250	8,000
	8	dsl	300	Wgnr-Mrhse 15-40	300	10,000
Oil Well Serv Co	9	LPG	400	Ideco 30	300	10,000
Los Angeles						
Wells Drlg Co	2	dsl	325	Mobile Blitz 622	350	7,500
San Joaquin County						
Santa Fe Drlg Co	11	gas	600	Wgnr-Mrhse	220	7,500
Ventura						
Terminal Drlg & Prod Co	18	dsl	500	Ideco H-525D	600	16,000
Wilmington						
Terminal Drlg & Prod Co	1	gas	620	Natl 50	450	12,000
	12	gas-LPG	320	Ideco H-30D	190	9,000
	14	gas-LPG	140	Ideco H-25D	125	3,500
	17	dsl	500	Wisn Mogul	350	12,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
COLORADO						
Sterling						
Miers Well Serv Inc	6	gas	400	Frnks 7000	400	10,000/2½"
	7	gas	400	Frnks 7000	400	10,000/2½"
KANSAS						
Graham County						
Veeder Supply & Dev Co	D	dsl	280	Natl T-25	300	4,500
McPherson County						
Veeder Supply & Dev Co		dsl	270	Frnks 658	270	8,000
ILLINOIS						
Centralia						
T M Pruett Drlg Contr	1	dsl	300	M-CSCO U-15	300	8,000
LOUISIANA						
Cameron						
Allied Well Serv Inc	6	gas-LPG	200	Crdwll	185	13,000
DeSoto Parish						
McCalman Drlg Co Inc	1	dsl	—	Brwstr N-4	300	8,000
Eunice						
T & H Well Serv Co	1	gas-gaso-btne	225	Wisn Spr 38	180	18,000
Evangeline Parish						
Harris Drlg Co Inc	3	gas	200	Crdwll RL	200	12,000/2"
	5	gas	155	Crdwll K	155	10,000/2"
Gonzales						
Win Hawkins Drlg Co	2	gas-btne	300	M-CSCO U-15	485	16,000
Hackberry						
Allied Well Serv Inc	Bge 16	gas-LPG	400	Brwstr N-45	400	15,000
Jefferson Parish						
Harvey Well Serv Inc	Bge 1	dsl	600	Frnks SAL 5000	600	7,500/3½"
Jennings						
Allied Well Serv Inc	14	gas-LPG	200	Brwstr N-4	185	13,000
	15	gas-LPG	200	Brwstr N-4	185	13,000
Lafourche Parish						
Cron & Gracey Corp	3	dsl	—	TIW CT-5	520	16,000
Plaquemines Parish						
Clinch Drlg Co	Bge 1	dsl	—	Emsco GA-350	426	8,500
Rayne						
Sunnyland Contr Co Inc	8	gas-btne	422	Crdwll D	422	13,000/2"
Ruston						
Johnson Drlg & Serv Co	2	dsl	500	Beth Twister	300	12,500
Shreveport						
C M Roberson Drlg Co	1	gas-btne	325	Brwstr N-45	370	15,000/2"
E B Duncan Drlg & Well Serv Co Inc	1	LPG	150	Frnks 5000	450	6,000/2½"
Springhill						
J C Williams Well Serv Co	9	dsl	220	Wisn Mogul	220	1,200
Terrebonne Parish						
Columbia Drlg Co	Bge 1	dsl	800	"Oilwell" 76	750	18,000
C G Glasscock Drlg Co	14	dsl	1500	Natl 75	900	15,000
Venice						
Gulf Tide Drlg Co	1	dsl	600	Wisn Spr Gnt	600	15,000
MISSISSIPPI						
Bolton						
Graham Bros Oil Well Serv	6	dsl	180	Crdwll K-201	190	13,500
Forrest City						
Dapsco Inc	1	LPG	150	Wisn Mogul Trcair	250	18,000
Jasper City						
Dapsco Inc	2B	LPG	175	Beth S-45	125	16,000
Natchez						
Thornbrugh Well Serv Co	9	LPG	125	Wisn Mogul	125	10,000
	21	dsl	140	Wisn Gnt	200	12,000
Wayne City						
Dapsco Inc	2	dsl	700	M-CSCO U-40	—	—
	3	LPG	250	Wisn Mogul Trcair	290	20,000
MONTANA						
Glendive						
Rocket Well Serv	1	LPG	200	Frnks 658	200	12,000/2"
	2	LPG	200	Frnks 658	200	10,000/2"
Signal Oilfield Serv Inc	10	dsl	250	Frnks 658/65	250	12,000
NEVADA						
Fallon						
Barry Well Drlg Co	2	dsl	200	—	—	8,000
NEW MEXICO						
Farmington						
Carroll Drlg Co Inc	6	dsl	—	M-CSCO U-15	—	7,000
	8	gas-LPG	—	Natl 75	—	10,500
	10	gas-LPG	—	Emsco 350	—	10,000
Signal Oilfield Serv Inc	6	LPG	150	Frnks 65/44	200	8,000
San Juan County						
San Juan Drlg Co	5	gas	213	Natl 40	213	6,000
	12	gas	213	Brwstr 70	213	5,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
OKLAHOMA						
Ardmore						
N & L Drlg Co	1	gas-btne	325	Brwstr N-4	200	12,000
Quad Drlg Co	1	gaso-btne	1000	Frnks Gnt Clipper	275	15,000
	2	btne	150	Crdwll KL	125	6,500
Carter County						
B M McGraw Drlg Contr	4	dsl	—	Frnks SAL 5000	400	6,500
Glenn Gillespie & Sons	7	dsl	300	Frnks 658 TRD	225	8,000
Noble County						
Chambless-Rosen Drlg Co	1	gas-btne	225	Crdwll RL	200	8,000
Oklahoma City						
Beckman Inc	3	gas	150	MIW P-42	200	10,000
	5	—	180	MIW P-42	175	10,000
	12	gas	150	MIW P-42	175	10,000
	17	gas	150	MIW P-42	200	10,000
	18	gas	150	MIW P-42	200	10,000
	19	—	180	MIW P-42	175	10,000
Okmulgee						
Twinoak Drlg Co	1	dsl	190	Frnks 3000	190	3,500
	1	dsl	190	Frnks	190	5,000
Osage County						
Glenn Gillespie & Sons	1	gas	360	M-CSCO U-34	225	8,000/2⅛"
TEXAS						
Alice						
Mohawk Oil Well Serv	2	dsl	125	Wisn Spr	125	7,500
	3	dsl	125	Wisn Spr	125	7,500
	4	dsl	125	Wisn Spr	125	7,500
W M & W Well Serv Co	9	dsl	300	Wisn Spr	150	4,000
Anderson County						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wisn Gnt	300	8,000
Aransas County						
Camden Drlg Co	Bge 2	dsl	600	Natl T-32	300	15,000
C G Glasscock Drlg Co	10	dsl	750	Natl 50	—	9,000
Bay City						
C B S Workover Co	3	gas-btne	200	Ideco H-30-D	200	12,000
Brazoria County						
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	7,500
Carrizo Springs						
Sutton Prod Co	9	—	—	—	—	4,000
Cayuga						
Mobile Well Serv	2	LPG	185	Wisn Spr	200	9,000
	3	LPG	185	Frnks T-87	209	10,000
	10	LPG	185	Frnks 65-44 DTD	200	9,000
Charlotte						
Sutton Prod Co	8	gas-gaso	—	Wisn	125	5,000
Colorado City						
W & C Well Serv	5	dsl-LPG	150	Wisn Spr 38	212	10,000
	6	dsl-LPG	150	Wisn Spr 38	212	10,000
Conroe						
Spur Well Serv Co	2	gas-gaso	100	Frnks 65-TD	180	8,000
Corpus Christi						
Bailey Well Serv Inc	1	gas-gaso-btne	160	Allis-Chmrs	160	10,000/2"
	2	gas-gaso-btne	160	Allis-Chmrs	150	10,000/2"
Carl Vickers Well Serv	1	gas-gaso-btne	308	Crdwll Trlrig	308	12,000
	4	gas-gaso-btne	160	Crdwll K-200	160	8,000
Corsicana						
Stroube Drlg Co	—	btne	175	Mayhew	175	2,000
Devine						
Douglas V Downing Well Serv	7	LPG	250	Wisn Spr	185	8,500
Freer						
General Well Drlg Inc	8	btne	400	—	185	8,000
Steitle Drlg Co	1	dsl	311	Wisn Mogul	302	16,000
Freestone County						
Gibson Drlg Co	4	gas-btne	226	Wisn Mogul	225	7,500
Houston						
Stewart's Casing Crew	1	gas-LPG	—	Cooper E	60	8,000/2"
	3	gas-LPG	—	Cooper 420	145	11,000/2"
	5	gas-LPG	—	Cooper 420	145	11,000/2"
	6	gas-LPG	—	Cooper 420	145	11,000/2"
	9	gas-LPG	—	—	145	10,000/2"
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	15,000
Spur Well Serv Co	1	gas-gaso	100	Frnks 65-TD	180	8,000
	3	gas-LPG-dsl	250	Frnks 137	580	12,000
Chet Whaley Well Serv Co	1	gas-gaso-btne	225	Wisn Gnt	225	8,000
	2	gas-gaso-btne	225	Wisn Gnt	275	8,000
Kilgore						
J-B Swabbing Co Inc	1	gas	300	Wisn Gnt	300	12,000
	1	gas	200	Wisn Mogul	250	10,000
Liberty						
Tex Workover & Oilwell Serv Co	2	gas-LPG	475	Brwstr N-4	450	14,000
Littlefield						
Price-Sitton Drlg Co	1	btne	270	Wisn Gnt	270	8,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drawwks	Workover Depth Ft.
Lodi						
Lodi Drlg & Serv Co	3	gas-LPG	—	Wisn Mogul 42	—	—
	6	dsl	—	Emsco 350	—	—
Los Angeles						
General Well Drlg Inc	3	btne	450	—	200	8,000
McCook						
General Well Drlg Inc	7	dsl	500	—	300	14,000
Mission						
J & M Well Serv	6	gas-gaso-LPG	305	Cooper L-145	136	12,000
Nueces County						
C G Glasscock Drlg Co	9	dsl	400	Natl T-20	—	7,500
Harold L Strader Drlg Co	Bge 401	btne	—	Brwstr N-4	—	13,500/2"
Odessa						
Beckman Inc	1	gas	185	M-CSCO U-15	350	6,000
	2	gas	185	Beth S-50	185	3,500
	11	gas	300	M-CSCO U-34	300	4,500
J E Perkins Inc	3	gas-LPG	175	Wisn Gnt	250	10,000
	4	gas-LPG	450	M-CSCO U-15	450	15,000
	5	gas-LPG	400	Wisn Gnt 42	400	12,500
	6	gas-LPG	450	Wisn Gnt 42	450	15,000
Pecos County						
Texas Drlg Co	1	gas	300	Natl T-20	300	6,000
Post						
Smith & Breyer	4	gas	530	Frnks	530	15,000
Rio Grande City						
J & M Well Serv	3	gas-gaso-LPG	67	Cooper E-563	67	6,500
	4	gas-gaso-LPG	67	Wisn Spr	67	7,500
	5	gas-gaso-LPG	67	Wisn Spr	67	7,500
Rosenberg						
Savely Workover & Drlg Co	2	gas-LPG	265	Natl T-12	230	11,000/2⅛"
	3	gas-LPG	200	M-CSCO U-34	235	12,500
Saratoga						
C B S Workover Co	1	gas-btne	250	Ideco H-30-D	200	12,000
Smith County						
Gibson Drlg Co	3	gas-btne	300	Wisn Gnt	275	9,000
Snyder						
Dave Harlin Drlg Co	1	btne	300	Beth S-45	300	8,000/2⅛"
	2	gaso	—	Cooper	200	7,500
	3	btne-dsl	355	Spencer	355	9,000
Stockdale						
Sutton Prod Co	5	gas-gaso	—	Wisn	125	3,500
Sullivan City						
General Well Drlg Inc	1	btne	250	—	185	6,500
Sulphur Springs						
Dood Emerson Well Serv & Gen Contg	2	LPG	180	Wisn Spr	145	4,500
Upshur County						
Gibson Drlg Co	2	gas-btne	226	Wisn Mogul 42	145	8,000
Victoria						
Glenn Drlg Co	3	gas	145	Crdwll S	145	7,000
Village Mills						
C B S Workover Co	2	gas-btne	200	Crdwll K	150	8,000
Wichita Falls						
McAlister Well Serv	16	LPG	80	Reverse Circ Rig	—	6,000
Wink						
Permian Well Serv Inc	1	LPG	200	Crdwll RL	290	12,000
Winnsboro						
Winnsboro Well Serv Co	F-1	btne	145	Frnks Rocket	178	7,200/2½"
	F-2	btne	145	Frnks Rocket	178	7,200/2½"
Wise County						
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	8,500
	2	gas-btne	150	Wisn Super	150	5,000
	4	gas-btne	150	Crdwll K-200	150	5,000
Wood County						
Gibson Drlg Co	1	gas-btne	275	Wisn Mogul 42	265	8,000
		WYOMING				
Casper						
M E Billings Well Serv Inc	1	LPG	165	Frnks 658	180	8,000
Cody						
Wyoming Well Serv Inc	24	gas	200	Frnks 5039	220	8,000

Some Casing Pulling Equipment

Contractor's Name	Rig No.	Description of Casing Pulling Equipment
		TEXAS
Houston		
Stewart's Casing Crew	—	Three truck-mounted units, equipped with 150-ton jacks to pull casing to 10,000 ft. Equipped to handle all P & A work.
Kilgore		
Potter Bros	1	Wisn Spr single drum servicing unit available for casing pulling jobs
	2	Crdwll single drum servicing unit available for casing pulling jobs
Midland		
Dean Penick Casing Pulling	—	Two casing pulling rigs complete: Wisn Spr single-drum truck-mounted. Pulling capacity; 150,000 lb on mast pole; 300,000 lb on jacks.
Snyder		
C E Knight & Co	—	3 truck-mounted units, range 3 pipe. Handle rods, tubing, mudding hole, spotting cement, circulating and shooting. 2 large rigs for pulling and plugging to 16,000 ft. A smaller unit for 8,000-ft jobs. Hydraulic jacks.
		ALBERTA PROVINCE, CANADA
Edmonton		
General Well Serv Ltd	—	Complete subsurface abandonment and casing pulling and shooting. Ft Houston Iron Works jacks and hydraulic pump. Single pole mast, single drum, trailer-mounted unit.
Prairie Well Serv Co Ltd	1	Factory-made—three-stage hydraulic jacks with single drum, Continental-powered drawworks.

Canadian Well Servicing Contractors

Alphabetical List

Beta Well Serv Ltd 5930-96 St Edmonton Alberta Canada
Calgary Oil Field Serv Ltd 133 6th Ave SE Calgary Alberta Canada
Coralta Drlg Ltd Box 4104 Edmonton, Alberta, Canada
General Well Servs Ltd 10955 66th Ave Edmonton Alberta, Canada
Kenyons Drlg & Serv Ltd 10439 82nd Ave Edmonton Alberta Canada
M W Drlg & Serv Ltd Suite A 328-A 8th Ave W Calgary, Alberta Canada
Prairie Well Serv Co Ltd Box 4177 Edmonton Alberta Canada
Redwell Serv Co Ltd 6530 100th St Edmonton Alberta Canada
Souris Serv Co Ltd 940 8th Ave West Calgary Alberta Canada
Virden Drlg Co Ltd Box 667 Virden Manitoba Canada
Widney Oil & Drlg Co Ltd 6328 104th St Edmonton Alberta Canada
Wright & Bruce Ltd Suite A 328-A 8th Ave W Calgary Alberta Canada

Canadian Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
		ALBERTA PROVINCE					
Bruton							
Redwell Serv Co Ltd	1	Crdwll H	Truck	1	9 000	7,000/2" 5,000/2½" 3,500/3"	No
Devon							
Kenyon's Oilfield Serv Co Ltd	7	Crdwll U	Truck	2	6,000	5,000/2½"	Yes
Widney Oil & Drlg Co Ltd	1	Ideco H-20	Truck	2	9,000	10,500/2" 9,000/2½" 5,500/3"	Yes
	6	Wisn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	7	Cooper W-226	Truck	2	5,000	3,000/2½"	No
	9	Wisn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	10	Frnks Rocket	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
	12	Ideco H-35	Self-prop	2	15,000	18,000/2" 15,000/2½" 8,000/3"	Yes
Drayton Valley							
Beta Well Serv Ltd	8	Crdwll K-201	Truck	2	—	10,000/2" 8,500/2½"	Yes
	10	Crdwll K-201	Truck	2	—	10,000/2" 8,500/2½"	Yes
Kenyon's Oilfield Serv Co Ltd	9	Crdwll AR	Truck	2	7,000	7,000/2½"	Yes
Edmonton							
Beta Well Serv Ltd	6	Crdwll AH	Truck	2	—	6,000/2"	Yes
	7	Crdwll L-150	Trailer	2	—	12,000/2" 10,000/2½"	Yes
	9	Cooper W-26	Truck	2	5,000	3,500/2½"	Yes
Kenyon's Oilfield Serv Co Ltd	4	Crdwll Mobilhoist	Truck	2	5,000	5,000/2½"	Yes
Prairie Well Serv Co Ltd	1	Crdwll H	Truck	1	6,000	6,000/2" 5,000/2½" 4,000/3"	No
	2	Crdwll H	Truck	1	6,000	6,000/2" 5,000/2½" 4,000/3"	No
	3	Crdwll Mbilhst	Self-prop	2	6,500	6,500/2" 5,500/2½" 4,500/3½"	Yes
	4	Ideco 50-60	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	Yes
	5	Crdwll KL	Skid Mtd	2	8,000	9,000/2" 8,000/2½" 6,000/3"	Yes
	6	Crdwll RL	Skid Mtd	2	14,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	9	Frnks	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	10	Cooper	Self-prop	2	9,000	10,000/2" 9,000/2½" 7,000/3"	Yes
Redwell Serv Co Ltd	6	Crdwll AH	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	9	Frnks Clipper 65	Truck	2	9,000	13,000/2" 10,000/2½" 7,000/3"	Yes
Pembina							
Redwell Serv Co Ltd	5	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	10	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
Red Deer							
Kenyon's Oilfield Serv Co Ltd	2	Crdwll H	Truck	2	6,000	5,000/2½"	Yes
	5	Frnks Sr	Self-prop	2	12,000	10,000/2½"	Yes
Redwell Serv Co Ltd	3	Crdwll H	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	7	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
	11	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
Redwater							
Beta Well Serv Ltd	2	Crdwll H	Truck	1	—	5,000/2" 4,000/2½"	Yes
	3	Crdwll Mobilhst	Truck	2	—	5,000/2" 4,000/2½"	Yes
Stettler							
Redwell Serv Co Ltd	2	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½" 3,500/3"	No
Sundre							
Kenyon's Oilfield Serv Co Ltd	8	Frnks Sr 658	Self-prop	2	12,000	14,000/2½"	Yes
Redwell Serv Co Ltd	8	Frnks Clipper 65	Truck	2	9,000	13,000/2" 10,000/2½" 7,000/3"	Yes
Wetaskiwin							
Calgary Oil Field Serv Ltd	1	Wisn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	2	Wisn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	3	Wisn Mogul 42	Truck	2	12,000	10,000/2½"	Yes
	4	Wisn Mogul 42	Truck	2	12,000	10,000/2½"	Yes
BRITISH COLUMBIA PROVINCE							
Ft. St. John							
Kenyon's Oilfield Serv Co Ltd	3	Frnks 658	Truck	2	9,000	7,000/2½"	Yes
MANITOBA PROVINCE							
Virden							
Virden Drlg Co Ltd	7	Crdwll Q	Truck	1	3,000	3,000/2" 2,500/2½" 2,000/3"	Yes
SASKATCHEWAN PROVINCE							
Estevan							
Virden Drlg Co Ltd	4	Crdwll H	Truck	2	6,000	6,000/2" 5,500/2½" 5,000/3"	Yes
Widney Oil & Drlg Co Ltd	8	Wisn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	11	Frnks Rocket	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
Oxbow							
Souris Serv Co Ltd	2	Frnks Rocket	Truck	2	6,000	6,000/2½"	Yes
	3	Crdwll AL	Truck	2	5,000	5,000/2"	Yes
Smiley							
Keyon's Oilfield Serv Co Ltd	6	Frnks Rocket	Truck	2	4,000	4,200/2½"	Yes
Weyburn							
Souris Serv Co Ltd	1	Crdwll AL	Truck	2	5,000	5,000/2"	Yes

Canadian Cable Tool Servicing Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	No. of Drums	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALBERTA PROVINCE							
Drayton Valley							
M W Drlg & Servg Ltd	1	dsl	135	—	—	6000	Crdwll H
	4	gaso	80	—	—	3000	Crdwll Q
	5	dsl	135	—	—	6000	Crdwll AH
	7	gaso	80	—	—	3000	Crdwll Q
	8	Wisn	—	—	—	12,000	Wisn Spr 38
Edmonton							
Prairie Well Serv Co Ltd	5	gas	140	2	—	5000	Crdwll KL
	6	dsl	185	2	—	7500	Crdwll RL
Medicine Hat							
Wright & Bruce Ltd	10	dsl	135	—	—	3500	B Erie 28-L
MANITOBA PROVINCE							
Virden							
Wright & Bruce Ltd	9	dsl	135	—	—	3500	B Erie 28-L
Virden Drlg Co Ltd	2	dsl	150	3	6000	6000	B Erie 36-L
	8	gas	85	3	3000	3000	B Erie 28-L
SASKATCHEWAN PROVINCE							
Coleville							
Wright & Bruce Ltd	4	gaso	100	—	—	3000	B Erie 24-L
	8	dsl	135	—	—	3500	B Erie 28-L
	14	dsl	135	—	—	6000	Crdwll AL
Estevan							
Wright & Bruce Ltd	1	gaso	80	—	—	3000	Crdwll Q
	11	dsl	135	—	—	6000	Crdwll AH
	12	dsl	135	—	—	6000	Crdwll AH
Shaunavon							
Virden Drlg Co Ltd	2	dsl	150	3	6000	6000	B Erie 36-L

Canadian Rotary Workover Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft.
ALBERTA PROVINCE						
Coronation						
Coralta Drlg Ltd	2	gas	180	Failing 1500	180	1,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
Edmonton						
Coralta Drlg Ltd	1	gas	180	Failing 1500	180	1,500
Kenyon's Drlg & Serv Ltd	11	dsl	—	Crdwll 151	350	10,000
Prairie Well Serv Co Ltd	4	gas	140	Ideco 50-60	140	6,000
	5	gas	140	Crdwll KL	140	6,000
	6	dsl	185	Crdwll RL	185	12,000
	9	dsl	185	Frnks	225	12,000
	10	gas	230	Cooper	232	9,000
Redwell Serv Co Ltd	13	dsl	260	Crdwll L350	260	13,000
	12	dsl	260	Crdwll L	180	10,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
MANITOBA PROVINCE						
Virden						
Virden Drlg Co Ltd	4	dsl	170	Crdwll H	150	6,000
	7	gas	170	Crdwll Q	110	2,500
SASKATCHEWAN PROVINCE						
Estevan						
Kenyon's Drlg & Serv Ltd	12	dsl	—	Frnks Comet 658	250	9,000
Oxbow						
Souris Serv Co Ltd	2	dsl	—	Frnks Rocket	114	5,000/2⅛"
	3	gas	—	Crdwll AL	144	5,000/2⅛"
Weyburn						
Souris Serv Co Ltd	1	dsl	—	Crdwll AL	114	5,000/2⅛"

ADDITIONAL LISTINGS

U. S. Contract Rotary Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
COLORADO						
Morgan County						
Lohmann- Johnson Drlg Co Inc	1	dsl	300	Natl 50	480	5,500
ILLINOIS						
Gallatin County						
Lohmann-Johnson Drlg Co Inc	6	btne	300	Crdwll S	440	4,500
INDIANA						
Posey County						
Lohmann-Johnson Drlg Co Inc	7	gas	300	Crdwll S	440	4,500
KANSAS						
Phillips County						
Lohmann-Johnson Drlg Co Inc	3	btne	300	Natl 50	450	5,500
KENTUCKY						
Henderson County						
Temple Drlg Co Inc	2	dsl	300	Crdwll S	440	4,500
NORTH DAKOTA						
Burke County						
Lohmann-Johnson Drlg Co Inc	4	dsl	300	M-CSCO U-15	440	5,500
OKLAHOMA						
Alfalfa County						
Lohmann-Johnson Drlg Co Inc	8	dsl	300	Natl 32	550	7,500
Kingfisher County						
Jones Shelburne & Pellow Oil Co	1	gas	450	Custom Spr Spd	450	7,500
McClain County						
Jones Shelburne & Pellow Oil Co	2	gas	1350	Natl 100	1350	14,000
	3	gas	675	Natl 50	675	8,300
	4	gas	700	Wlsn Titan	700	9,000
PENNSYLVANIA						
Indiana County						
Lohmann-Johnson Oil Co Inc	9	gas	750	"Oilwell" 66	500	10,000
Somerset County						
Lohmann-Johnson Oil Co Inc	2	gas	500	"Oilwell" 76	750	10,000

U. S. Cable Tool Rigs

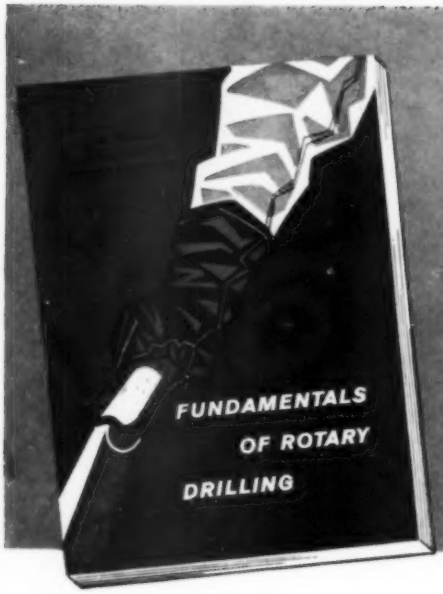
Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
KANSAS						
Butler County						
Strait Drlg Inc	1	gas	175	3500	4000	B Erie 36-L
OKLAHOMA						
Garvin County						
Jones Shelburne & Pellow Oil Co	1	gas	150	3500	4500	Wichita Spdr

Canadian Contract Rotary Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
SASKATCHEWAN PROVINCE						
L & J Drlg Co Inc	5	dsl	300	Crdwll S	440	4,500

U. S. Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity — Swabbing	Estimated Capacity — Pulling	Can Unit Also Drill?
KANSAS							
Great Bend County							
Jones Well Serv Co	2	Frnks ET-5000	Truck	1	5,000	5,000/2" 4,300/2½" 3,800/3"	No
Plainville County							
Jones Well Serv Co	1	Frnks 44-TM	Truck	1	5,000	5,000/2" 4,300/2½" 3,800/3"	No
LOUISIANA							
Vinton Parish							
Luke Fruge	2	Wlsn Mogul	Trailer	1	12,000	—	—
	3	Wlsn Spr	Truck	1	—	8,500/2½"	No
	4	Cooper	Trailer	1	12,000	—	No
	5	Cooper 42	Truck	1	—	12,000/2½"	No
	6	Cooper 42	Truck	—	—	12,000/2½"	No
	7	Wlsn Mogul	Skid	1	—	12,000/2½"	No



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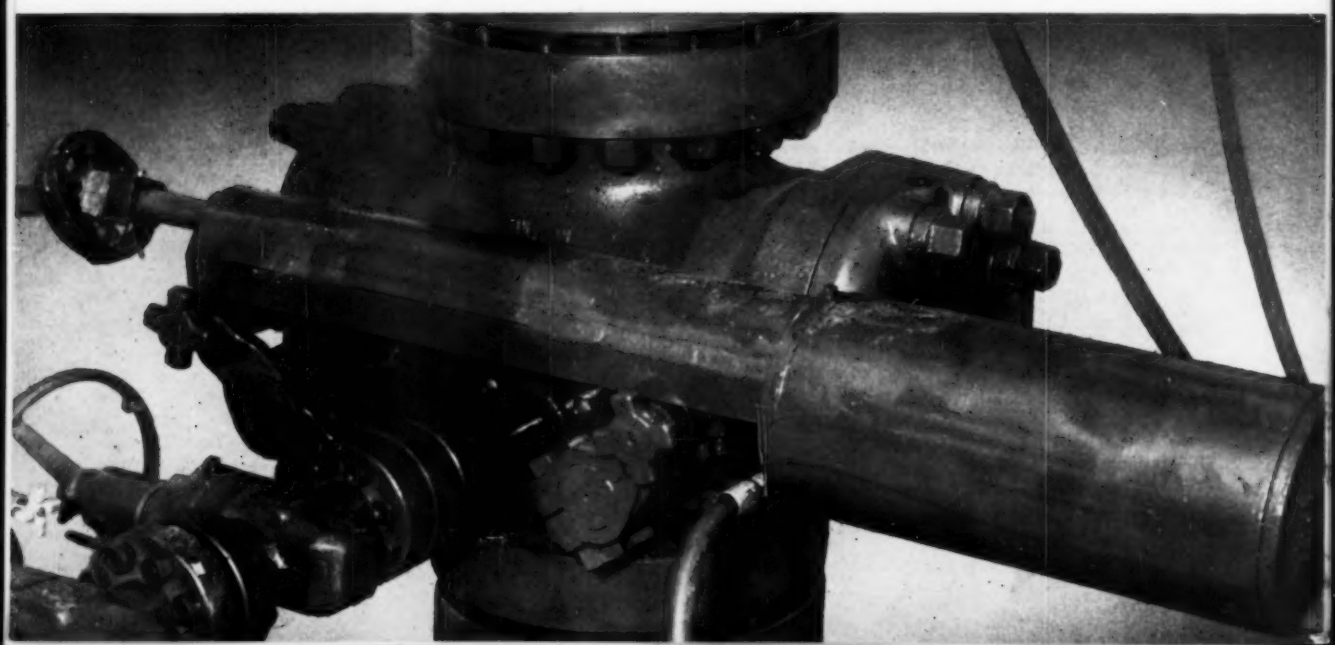

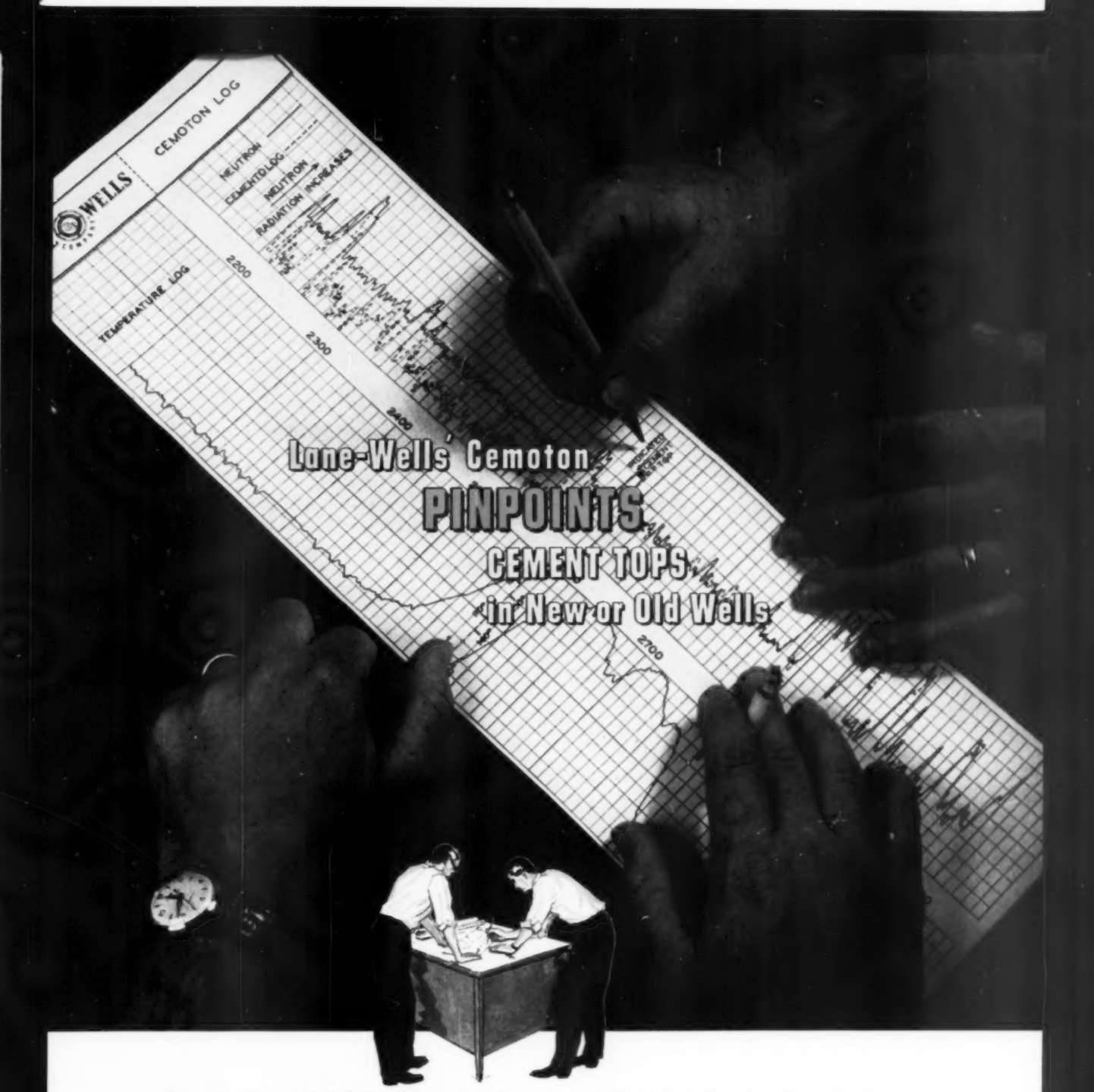

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